21 ~~A-P~~

DECEMBER 13, 1956
EVERY OTHER THURSDAY

# MACHINE DESIGN

A PENTON PUBLICATION

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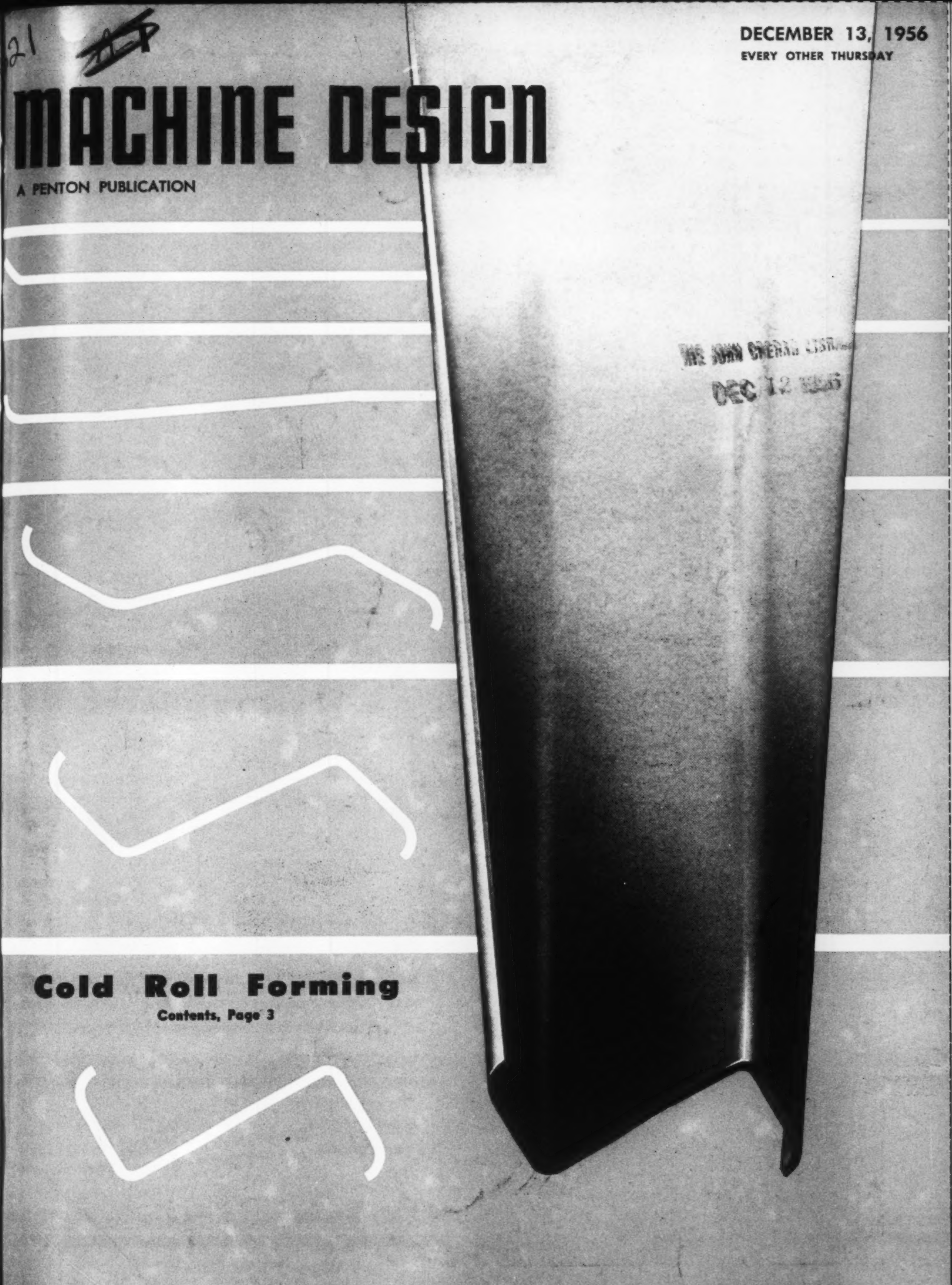

## Cold Roll Forming

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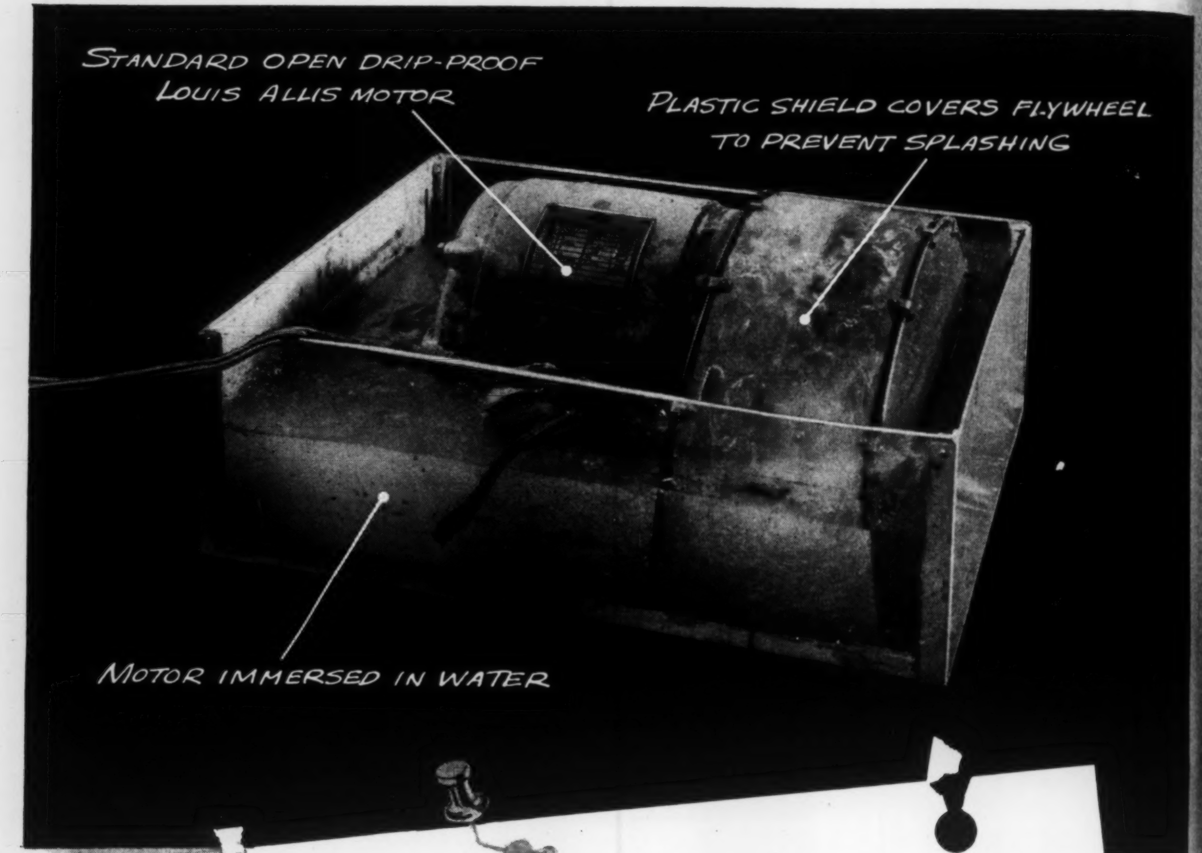
SWORTH


STANDARD OPEN DRIP-PROOF LOUIS ALLIS MOTOR
PLASTIC SHIELD COVERS FLYWHEEL TO PREVENT SPLASHING
MOTOR IMMERSED IN WATER

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We wouldn't do this to a motor. But somebody did, to check our new insulation. They took a standard open drip-proof motor, placed it in water up to the shaft, and ran it a year and a half.

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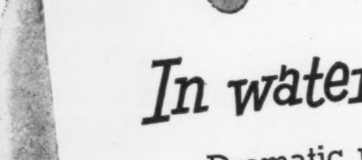
Find out the many other advantages available to you in the new L. A. line of motors. Write for our new bulletin No. 1700.



A complete line of standard rerated motors in frames 182 through 326U now in stock. Special rerated motors are available on short delivery.

LA-107

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MILWAUKEE 7, WISCONSIN

Circle 501 on page 19

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*Circle 504 on page 19*

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*Circle 505 on page 19*

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

December 13, 1956
**Volume 28—No. 25**

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XUM

# BRASS keeps sales up... manufacturing costs down

## TURNER IS A LONG-TIME USER OF ANACONDA BRASS ROD AND TUBE— GIVES 10 REASONS WHY—

Blow torches built by The Turner Brass Works, Sycamore, Ill., have a reputation for dependable operation and long life. Since 1871, brass has been used consistently in their construction and has built a quality reputation for Turner. Turner prefers Anaconda Brass as a quality metal and looks to The American Brass Company as a quality source of supply.

5673

These are the reasons given:

① Brass is the quality material needed for the service.

② Brass is easily machined at high speed, with less tool breakage—manufacturing costs are 15% lower than with other metals.

③ Close tolerances are easily held with brass.

④ Threading holds well—yet accessories are easily screwed on and off.

⑤ Brass takes a good finish—polishing is easy and economical.

⑥ Clean, polished brass products have proven high sales appeal.

⑦ Brass stands up under alternate heating and cooling.

⑧ Brass resists corrosion—the torches are used on land and sea, throughout the world.

⑨ Brass gives superior wear on valve seats.

⑩ Brass has high public acceptance as a quality material.

Turner liquefied petroleum torch No. LP-555, with disposable fuel tank. Below are accessories of brass—holder for soldering tip and a heavy-duty burner.

*The American Brass Company, Waterbury 20, Conn.*
*In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

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# Engineering News Roundup

## *Newest Jeep Puts Driver 'Way Up Front*

TOLEDO, O. — "Forward control" design is featured in the newest model Jeep recently introduced by Willys Motors Inc. The driver's seat in the new four-wheel drive truck is actually forward of the engine, permitting a view of the road up to 6 ft from the front bumper. Payload bed length behind the cab is more than 6 ft although the truck's wheelbase is only 81 in.

Designated FC-150, the new truck uses the Willys F-head "Hurricane" engine common to both military and civilian model Jeeps. Standard transmission provides nine forward speeds and three reverse. An optional transmission provides 12 forward speeds. Four-wheel drive can be engaged without stopping the truck.

**Engine Specifications**

| | |
|---|---|
| Type | OHV, F-Head |
| No. cyls. | 4 |
| Bore & stroke (in.) | 3⅛ x 4⅜ |
| Displ. (cu in.) | 134.2 |
| Comp. ratio | 6.9 to 1* |
| Bhp, max. | 75 @ 4000 |
| Torque, max. (lb-ft) | 115 @ 2000 |

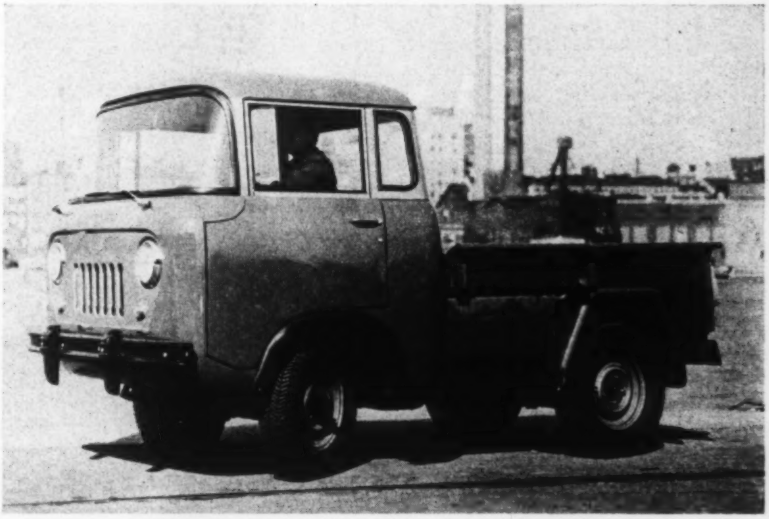
*7.4 to 1 optional.

**Size and Weight**

| | |
|---|---|
| Wheelbase (in.) | 81 |
| Length (in.) | 147½ |
| Width (in.) | 71⅜ |
| Height (in.) | 77⅜ |
| Curb weight (lb) | 2925 |
| Gross vehicle weight (lb) | 5000 |

The FC-150 can be equipped with power takeoff at three points. Center takeoff delivers power to equipment mounted in the truck bed. Front and rear points supply power for winches or belt and shaft-driven equipment.

Turning radius of the FC-150 is 18 ft. Claimed on-highway gas economy is 300 miles on a full tank of 16 gallons.



Newest Jeep is the FC-150 model which places the driver well forward to provide good visibility and to give maximum cargo body length.

THROUGH CONCRETE WITHOUT NOISE this new machine saws holes from 1 to 6 in. in diameter at the average rate of 1 in. per minute. The machine's saw bit is faced with industrial diamonds seated in high-test steel. A built-in counterbalancing device makes external pressure unnecessary. A 115 or 230 v motor drives the new machine made by J. F. Hamlin Co. and called Kor-It.

## *Future Cars May Have More But Smaller Instruments*

### Refinements Due In Other Car Accessories

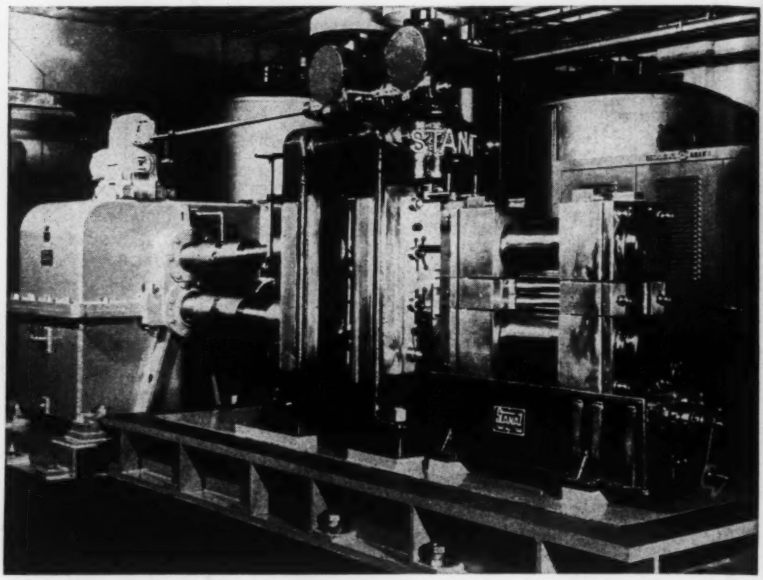
FLINT, MICH. — New instruments for passenger cars of the future may include an indicator for the water level in the cooling system and another for the oil level in the crankcase. These and the present instruments may be smaller than current styles but will give a wider sweep indication, as much as 270 degrees.

Prospects for the new gages and other automobile accessories were discussed recently by Martin J. Caserio, chief engineer, automotive products, AC Spark Plug Div., at a conference of automotive writers in the main AC accessory plant.

Indicating trends in automotive instrumentation, Mr. Caserio noted that the Redliner-type speedometer introduced in the 1954 Buick has been extended to the Pontiac line for 1957. Current model Buicks can also be equipped with the Safety-Minder speed warning device. A control knob on the Buick instrument panel can select speeds from 20 to 110 mph in increments of 5 mph. A buzzer sounds when the car reaches the preselected speed. Future models of the Safety-Minder may be set with an insert key.

More extensive use of printed circuits for instrument clusters is a strong possibility. The first application is in the 1957 Oldsmobiles. Electric speedometers are also under development, and new designs of spark plugs will be required for future engines with compression ratios as high as 12 to 1.

Higher performance engines create a demand for higher performance accessories. Two new types of air cleaners have been introduced. One is made of resin-impregnated paper with plastisol end seals. Another uses bonded hog's hair. Fuel cleaners, too, must be improved as a result of the introduction of fuel injection. One model recently developed filters particles as small as 10 microns, and future designs may be required to remove particles as small as 3 microns.



Working section of this rolling mill, including the roll change slide and mechanism, will be completely enclosed when nuclear materials are processed.

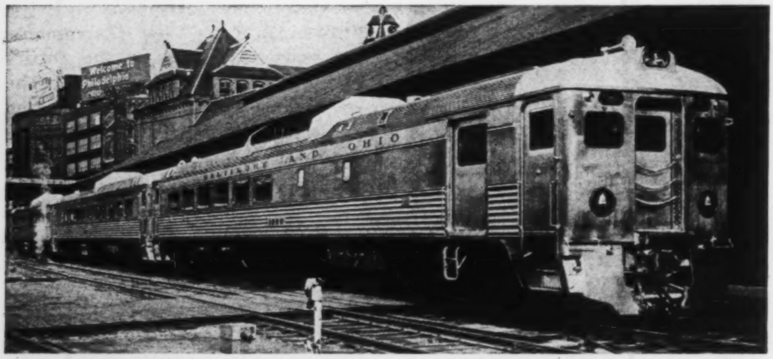
## Mill Fully Enclosed Will Roll Nuclear Reactor Parts

Long Island City, N. Y.—A completely enclosed working section is the unusual feature of a new rolling mill developed to process dangerous materials for use in nuclear power fuel elements and reactor structures. Built by the Stanat Mfg. Co., two of the new mills will soon be in operation at the Argonne National Laboratory, Lemont, Ill. Materials to be rolled include plutonium, uranium, zirconium, beryllium and thorium.

The machine is a combination 2-high/4-high mill with 2½-in. diam work rolls and 10-in. diam backup rolls. Spindles are capable of transmitting 50 hp at the lowest mill speed of 15 rpm. They drive the backup rolls in 4-high operation and the work rolls, directly, in 2-high operation.

The work zone of the mill will be enclosed in an airtight structure containing a helium atmosphere. Operation and maintenance are performed through arm-length gloves.

A slideway and slide mechanism in the machine enclosure is provid-

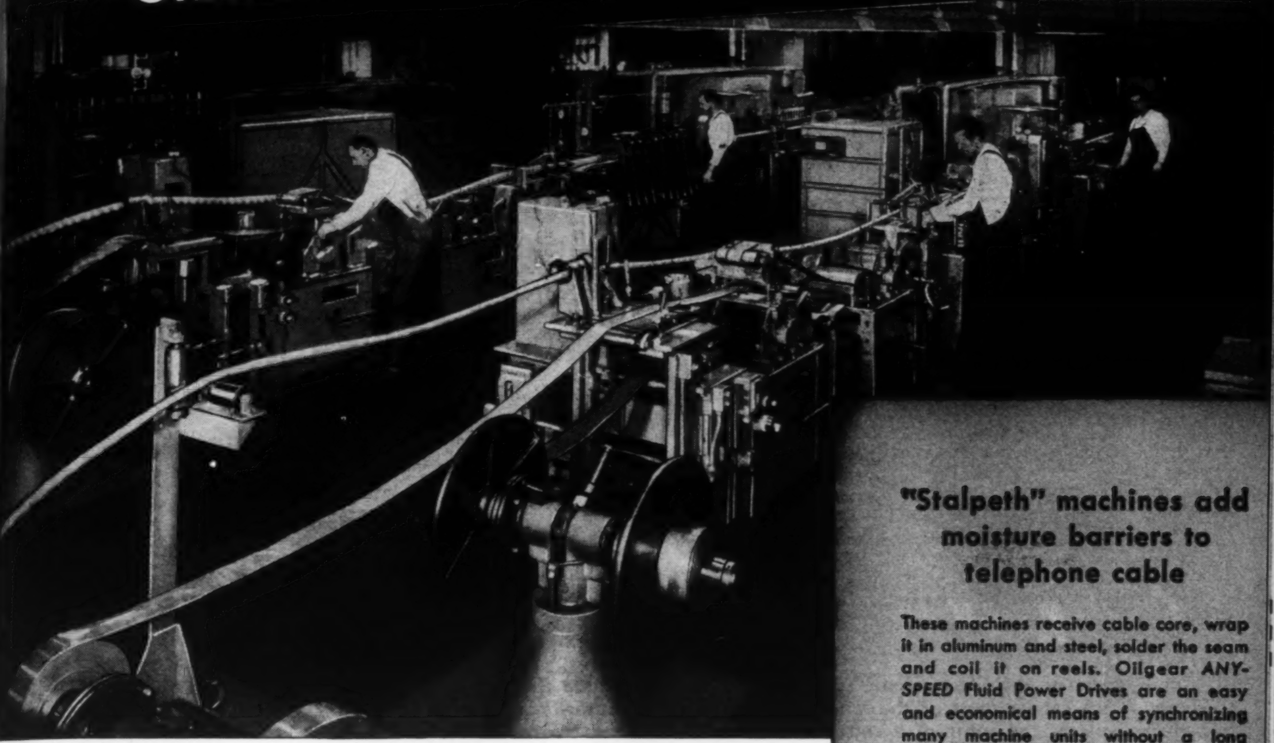


HIGH-SPEED LONG RUNS will be the performance of this new train, called the Speedliner, recently put into regular service on the Baltimore and Ohio Railroad between Philadelphia and Pittsburgh via Washington. Two identical trains starting at opposite ends of the 435-mile run will operate on an 8½-hr all-daylight schedule. Each train consists of three stainless-steel rail diesel cars built by the Budd Co. One of the three is a combined baggage-diner-reclining seat coach, the first in this type of equipment. On each car, two 300-hp diesel engines mounted under the floor transmit power to the trucks through torque converters. The engines can be removed and replaced like spare tires. The train accelerates from 0 to 70 mph in 2½ minutes.

### Front Cover

**Roll forming, in which a strip of metal is progressively bent by rolls to a final shape, is a continuous, high-speed process. Artist George Farnsworth has emphasized this continuous operation as a keynote for the front cover. Article providing the theme is by Richard T. Angel and begins on Page 106.**

# OILGEAR FLUID POWER DRIVES



## "Stalpeth" machines add moisture barriers to telephone cable

**These machines receive cable core, wrap it in aluminum and steel, solder the seam and coil it on reels. Oilgear *ANY-SPEED* Fluid Power Drives are an easy and economical means of synchronizing many machine units without a long lineshaft.**

## Solving the problem of close synchronization of driven members

As machines become more and more complex, combining more and more functions into a single unit, the problem of driving these machines successfully becomes more difficult.

This problem confronted Western Electric Company engineers in designing what they call their "Stalpeth" machines, two of which are shown above. These machines combine corrugating of steel and aluminum strips, forming them around the cable core, soldering the seam and then winding the assembly on reels at the far end. All of the members of the machine must be synchronized to the speed of the capstan unit. Going by their experience with other somewhat similar machines, Western Electric engineers again turned to Oilgear *"Any-Speed"* Fluid Power Drives, to solve what is really a complex problem ordinarily. Oilgear units provided an easy and economical means of synchronizing many machine components.

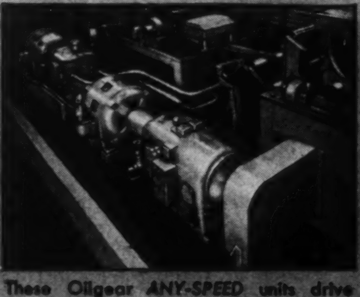
Oilgear *Any-Speed* Fluid Power Drives and transmissions *do* offer many machine design advantages including ease of control and synchronization of driven members, steplessly variable speed, fundamentally simple circuits, and long, trouble-free life. Write for Oilgear drive bulletins. THE OILGEAR COMPANY, 1568 W. Pierce St., Milwaukee 4, Wisconsin.

**OILGEAR**
*Fluid Power*

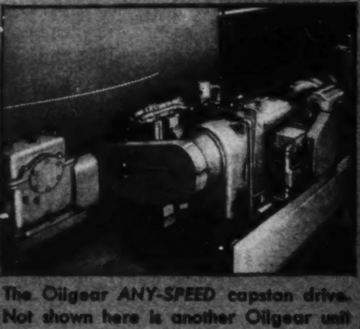
**PIONEERS . . . NOW THREE PLANTS FOR FLUID POWER**

**PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS AND VALVES**

*Circle 507 on page 19*

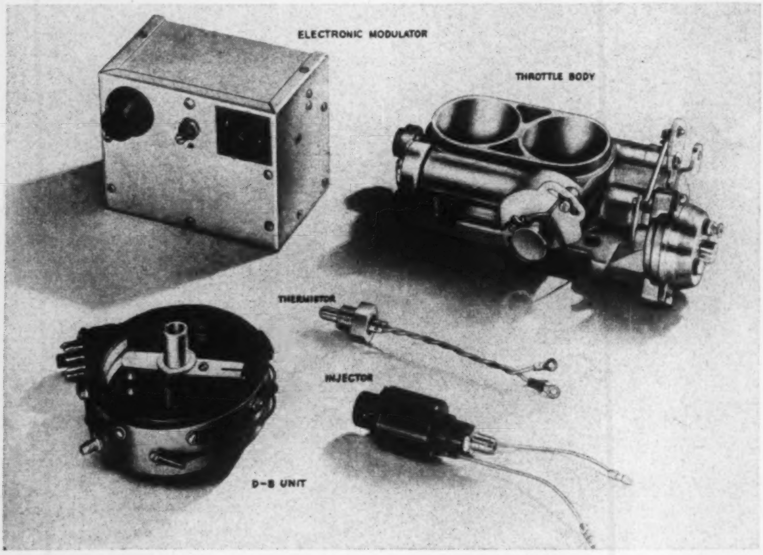


**These Oilgear *ANY-SPEED* units drive the aluminum and steel corrugator units in perfect unison with the governing capstan unit.**



**The Oilgear *ANY-SPEED* capstan drive. Not shown here is another Oilgear unit driving the cable winding reels.**

ed for roll changing. A motor-driven screw actuates the slide mechanism which inserts or withdraws the entire roll assembly as a unit. An overhead crane is also available within the enclosure to remove roll assemblies from the roll change slideway.



Components of the Electrojector fuel injection system include the throttle body which carries most of the sensing elements, a distributor-breaker unit which replaces the rotor of a conventional distributor, and the modulator which coordinates the signals and also compensates for altitude.

## *Fuel Injector for Auto Engines Has Electronic Components*

ELMIRA, N. Y.—Electronic components are featured in a new fuel injection system developed by Bendix Aviation Corp. for use on passenger automobiles. Called Electrojector, the system is said to be the first that does not require a special drive off the engine. Current production V-8 engines modified with the Electrojector for test purposes have shown better fuel performance than the same engines equipped with a four-barrel carburetor.

The new injection system consists of an electronic modulator, a fuel-injection distributing commutator, fuel-injection breaker points, and fuel-injection nozzles especially designed to minimize dirt problems.

The timing, sensing, and actuating elements, which automatically control fuel flow to the engine, operate from an electronic pressure sensor located on the throttle body. Also on the body is an electronic switch to sense and signal the need for proper fuel mixture, either for acceleration or idling. A third component on the throttle body is an automatic cutoff switch that should cut down the smog problem created by exhaust gases.

A thermistor is located in the water jacket to sense and pass along temperature data to the electronic modulator for optimum performance in start and warm-up.

The commutator and the breaker points which comprise the distributor-breaker of the new system can be installed on any conventional distributor. They add only an inch to the height of the assembly.

The "brain" of the new system is the transistor-equipped electronic modulator. It receives a timed signal from the distributor-breaker which it coordinates with information from the devices that electronically sense engine operating conditions. The modulator sends action signals continuously to injectors at the intake ports.

# Topics

**Shorter TV tubes** will make possible more compact sets. Expected to find wide use in portable sets, the new tubes are around 5 in. shorter than present types and are considerably lighter. Indications are that smaller size receivers will carry smaller price tags too.

• • •

Edsel, favorite of all rumored names for Ford's Model E, has been announced as the official name for the new line. Commenting on choice of the name, a company official explained that Edsel Ford was primarily concerned with styling and that the new car will establish "a new motif in styling."

• • •

**Speed and altitude records** have been set by a Sikorsky S-56 twin-engine helicopter. Speed was 162.7 mph; altitude, 7000 ft with a 13,250-lb payload.

• • •

**Faster patent processing** is the objective of a program begun recently by the U. S. Patent Office. Goal is to reduce the present 3½-year wait for a patent to two years by 1965. Patent Commissioner Robert C. Watson feels that less delay in granting patents will reduce risk of infringement on pending patents and will stimulate invention. Meanwhile the mid-1956 backlog of over 200,000 applications will increase by an expected 80,000 by next June.

• • •

**Simplified drafting** as a means to cut costs and increase productivity was discussed by General Electric drafting consultant Arthur H. Rau at the Drafting Practices Institute conducted recently by the University of Wisconsin. GE is teaching its 5000 draftsmen new techniques to produce functional drawings in minimum time.

• • •

American Society for Testing Materials has formed a subcommittee to study the effects of nuclear and high-energy radiation on the properties of plastics and electrical insulation. The society's decision to form this committee was based on the fact that existing data in the field of radiation effects on materials are in many cases confusing or contradictory.

Circle 508 on page 19→

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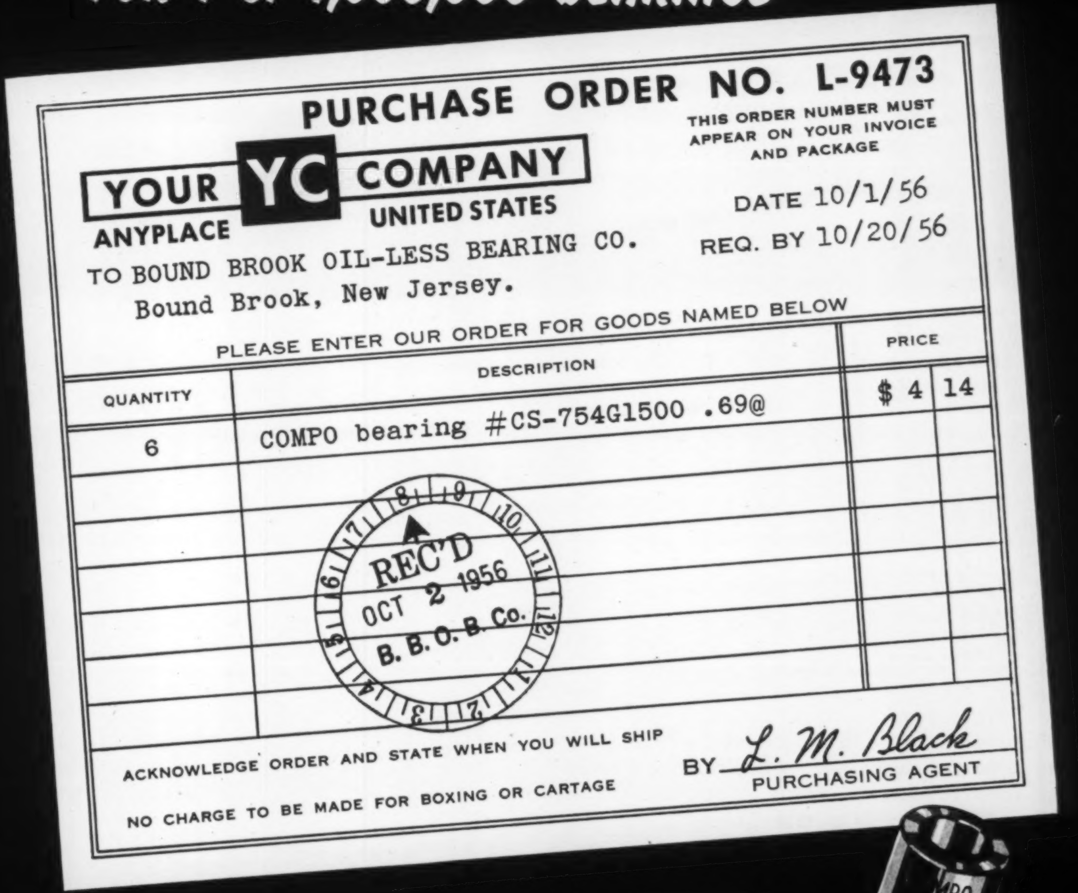

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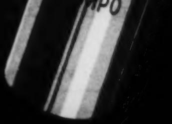

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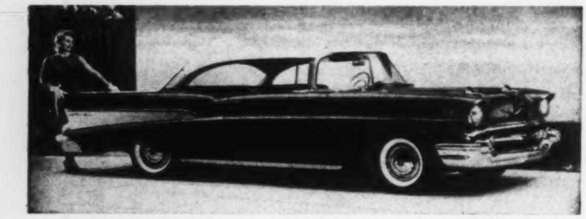
# Rounding Up the 1957 Automobiles—3

THE six automobiles in this issue have the characteristic long, low look for 1957. All but one have been restyled extensively to achieve this effect. Rear fins have been added or have grown; dual headlights can be obtained on some of the cars; windshield area has increased in most models. Several of the cars have pushbutton automatic transmissions; horsepower is higher; four-barrel carburetors are offered as standard or optional equipment; and one make offers a fuel injection system.

## CHEVROLET

Twenty different body styles are included in Chevrolet's 1957 line. Seventeen exterior colors, seven of which are new, make possible 16 solid colors and 15 two-tone combinations. The new car is longer and lower than last year's model and has a lowered hood, which permits increased windshield area. A new ventilating system takes in air through screens over the headlamps and delivers it to the passenger compartment through louvered outlets at each end of the dashboard. Wheels are 14-in. diam.



One six-cylinder and four V-8 engines power the 1957 Chevrolets. Available on any model, the 283-hp Corvette engine introduces Ramjet fuel injection. In operation, the accelerator pedal controls the volume of air; the air volume in turn determines the amount of gasoline delivered through the nozzles of the injector. A high-pressure pump, submerged in a fuel reservoir and driven by the distributor, supplies the pressure behind the gasoline.

**Engine Specifications**

| | | | |
|---|---|---|---|
| Type | In-Line | OHV, Vee | OHV, Vee |
| No. cyls | 6 | 8 | 8 |
| Bore & stroke (in.) | 3.56 x 3.94 | 3.75 x 3.00 | 3.87 x 3.00 |
| Displ. (cu in.) | 235.5 | 265 | 283 |
| Comp. ratio | 8.0 to 1 | 8.0 to 1 | 8.5 to 1* |
| Bhp, max | 140 @ 4200 | 162 @ 4400 | 185 @ 4600 |
| Torque, max (lb-ft) | 210 @ 2400 | 257 @ 2400 | 275 @ 2400 |

*9.5 to 1 with four-barrel carburetor, dual four-barrel carburetor or fuel injection.

**Size and Weight**

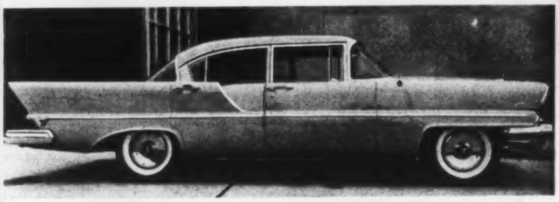
| | |
|---|---|
| Wheelbase (in.) | 115.0 |
| Length (in.) | 200.0 |
| Width (in.) | 73.9 |
| Height (in.) | 59.9 |
| Weight (lb) | 3290 |

New Turboglide transmission, consisting of three turbines and two planetary gearsets combined with a variable-pitch stator and the conventional torque converter pump, provides uninterrupted driving force at all speeds. This transmission has a hill retarder position, whereby a turbulence is created in the oil in the converter to impart a drag on the rear wheels. Powerglide, overdrive, and manual gearshift continue to be available.

## LINCOLN

Seven models comprise the Lincoln line for 1957. A four-door hardtop, called the Landau, and a thin pillar sedan are available in both the Premiere and Capri series. There is also a hardtop coupe in both series and a convertible in the Premiere series. The thin pillar sedans look like four-door hardtops when the side windows are rolled up. When the windows are turned down, a thin chrome pillar is visible.

Distinguishing feature of 1957 Lincolns are four road lights in vertical pairs, called Quadra-Lites. The auxiliary road lamps, positioned below the headlights, are optional equipment and may be used either alone or with the headlights.



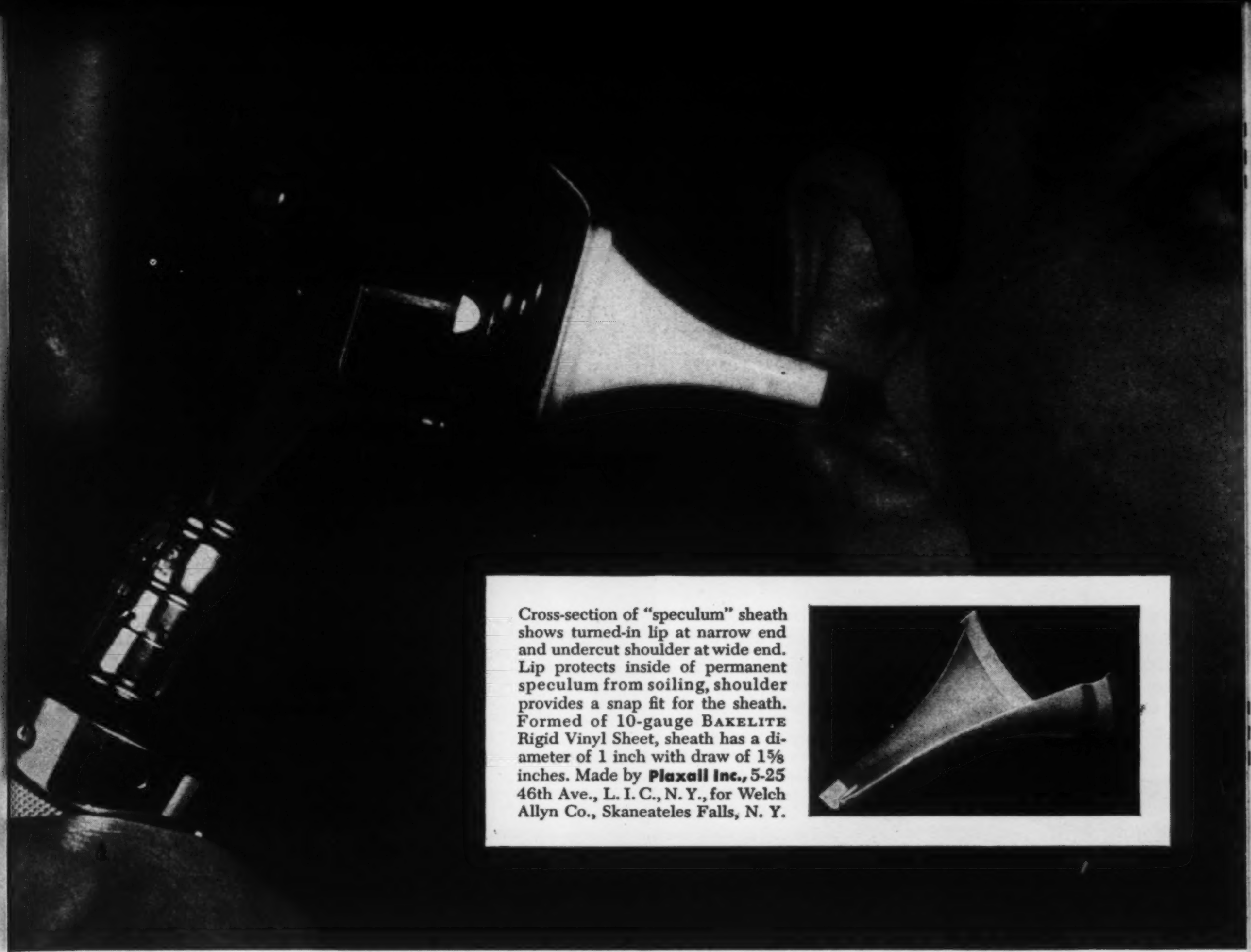
**Engine Specifications**

| | |
|---|---|
| Type | OHV, Vee |
| No. cyls | 8 |
| Bore & stroke (in.) | 4.00 x 3.66 |
| Displ. (cu in.) | 368 |
| Comp ratio | 10 to 1 |
| Bhp, max | 300 @ 4800 |
| Torque, max (lb-ft) | 415 @ 3000 |

**Size and Weight**

| | |
|---|---|
| Wheelbase (in.) | 126 |
| Length (in.) | 224.6 |
| Width (in.) | 80.3 |
| Height (in.) | 60.2 |
| Weight (lb) | 4500 |

Compression ratio and horsepower rating in the new Lincolns are both higher than in 1956 models, but engine displacement remains at 268 cu in. A new four-barrel carburetor has larger float bowls, and



Cross-section of "speculum" sheath shows turned-in lip at narrow end and undercut shoulder at wide end. Lip protects inside of permanent speculum from soiling, shoulder provides a snap fit for the sheath. Formed of 10-gauge BAKELITE Rigid Vinyl Sheet, sheath has a diameter of 1 inch with draw of 1⅝ inches. Made by **Plaxall Inc.,** 5-25 46th Ave., L. I. C., N. Y., for Welch Allyn Co., Skaneateles Falls, N. Y.

## *BAKELITE Rigid Vinyl Sheet makes possible this*
BRAND

# Intricate, accurate, disposable part

The design idea is a reality because BAKELITE Brand Rigid Vinyl Sheet was the only material that could be vacuum-formed to so deep a draw, according to the manufacturer. It's a sanitary disposable sheath for the "speculum" of an "otoscope" used in ear examinations.

These sheaths cost only a little over a cent apiece because pressure-forming BAKELITE Rigid Vinyl Sheets is such a fast, low-cost process. Notice the deep, complex draw. Precise, too. The sheath works in close quarters. It has to be thin, tight-fitting, and strong enough to be snapped onto the speculum without crinkling or tearing.

One material—BAKELITE Rigid Vinyl Sheet—met all requirements. In addition, its service properties include *dimensional stability* and resistance to water, oil, and chemicals. Clear transparent, as well as colored translucent and opaque sheet stock is available. Learn more about it by writing Dept. VU-103.

BAKELITE
BRAND
PLASTICS

**BAKELITE COMPANY,** *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.
*In Canada:* Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario
The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC.

***Circle 509 on page 19***

ignition timing at all engine speeds has been improved through a new distributor.

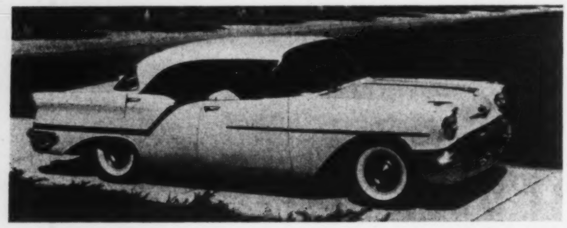
Power brakes are standard equipment on all seven models. In the Premiere and Capri series, power steering and Turbo-Drive transmission are standard. The Premiere also has a four-way power seat and power windows as standard equipment.

Optional accessories in both series are a six-way power seat, electric door locks, pushbutton lubricator, power-directed differential, and air conditioning.

## OLDSMOBILE

The 1957 Oldsmobile line consists of three series of cars in 17 body styles. Four body styles are new—three Fiesta station wagons and an "88" convertible coupe. The cars are 2 in. lower and 5 in. longer than last year's models.

Other styling changes include wider bumpers front and rear, two rows of beading on the roof and rear deck, sculptured rear fenders, and parallel chrome strips along the side with a contrasting color paint between. This "accent stripe" is the dividing line on two-tone models and is available in eight colors, six of which are also used as body colors.



**Engine Specifications**

| | |
|---|---|
| Type | OHV, Vee |
| No. cyls | 8 |
| Bore & stroke (in.) | 4 x $3\frac{11}{16}$ |
| Displ. (cu in.) | 371 |
| Comp. ratio | 9.50 to 1 |
| Bhp, max | 277 @ 4400 |
| Torque, max (lb-ft) | 400 @ 2800 |

**Size and Weight**

| | Golden Rocket "88" Series | Super "88" Series | Starfire "98" Series |
|---|---|---|---|
| Wheelbase (in.) | 122 | 122 | 126 |
| Length (in.) | 208.2 | 208.2 | 216.7 |
| Width (in.) | 76.4 | 76.4 | 76.4 |
| Height (in.) | 58.2 | 58.2 | 58.2 |
| Weight (lb) | 4000 | 4049 | 4347 |

The new Oldsmobile's instrument panel is mounted on struts and is the width of the car's body. This type of mounting provides a setback from the base of the windshield to allow air circulation and to provide maximum driver accessibility to the instruments. The instrument cluster employs a printed circuit, which reduces the number of electrical connections from 14 to one. A printed circuit is also used in the radio that is available for these cars.

Frame of the 1957 Olds is 8 in. wider than that of the 1956 model. It is also heavier. Front suspension is designed to prevent brake dip. Rear shock absorbers are positioned outside the leaf springs to provide a wider spring base and to reduce roll on curves. Wheels are 14 in. diam. The four-barrel quadri-jet carburetor is standard on all series.

## MERCURY

The 1957 Mercury is distinguished by a low silhouette, a larger body, a choice of two engines, and air-cushion rear suspension on many models. A total of 15 models are available in Monterey, Montclair and station wagon series.

The air-cushioned rear suspension is featured on all six station wagon models and is available on all other models with the optional 290-hp engine except the convertible. An air cushion the size of a tire 6 in. by 1½ in. is inserted between the frame and the front eye of the rear spring.

Other features contributing to riding qualities are longer front and rear springs, and a wider and heavier frame. Chassis features include a heavy straddle-mounted rear axle, low-pressure tires on 14-in. rims, longer wheelbase, wider front tread and wider brakes.

The compression ratio of 9.75 to 1 is the highest of any Mercury engines. The 290-hp engine with automatic transmission is optional on all 1957 models. The 255-hp engine is standard. Both engines have a four-barrel carburetor.

Keyboard automatic transmission control is standard on Montclair models and on Voyager and Colony

**Engine Specifications**

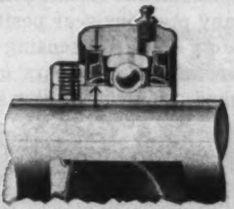
| | Safety-Surge | Turnpike Cruiser |
|---|---|---|
| Type | OHV, Vee | OHV, Vee |
| No. cyls. | 8 | 8 |
| Bore & stroke (in.) | 3.80 x 3.44 | 4.00 x 3.66 |
| Displ. (cu in.) | 312 | 368 |
| Comp ratio | 9.75 to 1 | 9.75 to 1 |
| Bhp, max | 255 @ 4600 | 290 @ 4600 |
| Torque, max (lb-ft) | 340 @ 2600 | 405 @ 2800 |

**Size and Weight**

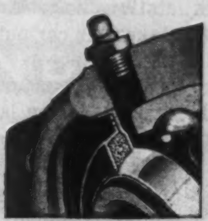
| | Monterey and Montclair Models | Station Wagon |
|---|---|---|
| Wheelbase (in.) | 122 | 122 |
| Length (in.) | 211.1 | 212.3 |
| Width (in.) | 79.2 | 79.2 |
| Height (in.) | 57.0 | 58.3 |
| Weight (lb) | 4000* | .... |

*With automatic transmission and 290-hp engine.

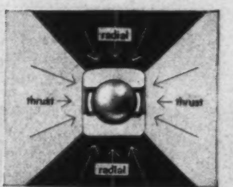
## MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings



**POSITIVE PROTECTION** from moisture, dust and dirt is provided by self-aligning seals extending from housing to inner ring. Aligning surfaces are enclosed and lubricated, assuring free alignment.



**AUTOMATIC RELIEF OF EXCESS GREASE PRESSURE** is provided through lubrication fitting and patented seal arrangement. Extra large grease capacity extends lubrication intervals.



**HIGHEST CAPACITY** available to carry radial, thrust or combination radial-thrust loads is provided by single-row, deep-groove design.

**RUGGED HOUSINGS** result from superior foundry practices. Base is cored to assure stress-free, maximum-strength casting.

◀ **DIRTY CONDITIONS** around this portable asphalt mixer manufactured by K. E. McConnaughay Co., Lafayette, Ind., make Link-Belt ball bearings the logical choice.

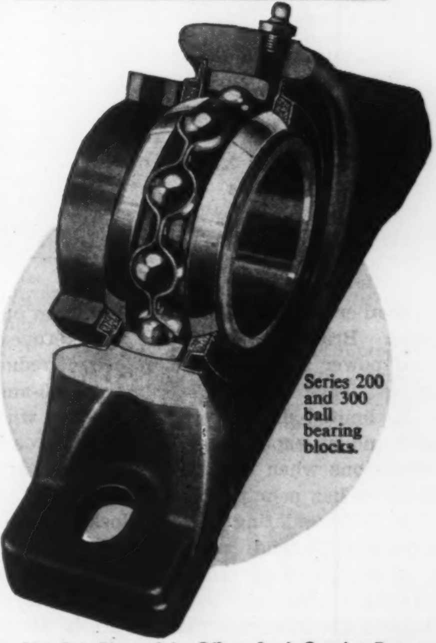
# grease stays in, dirt out

## thanks to the effective sealing of Link-Belt ball bearings

Here's an important extra only Link-Belt gives you on ball bearing blocks! *It's an exclusive seal arrangement*—all aligning surfaces as well as rolling elements are fully lubricated and sealed, assuring long, maintenance-free performance.

All seals are self-aligning—extra assurance that grease stays in, dirt stays out, regardless of alignment. The single-row bearing, too, is self-aligning—in all directions. Free rolling and full load capacity are maintained despite shaft deflection or misalignment.

Both Link-Belt ball and roller bearings offer the "fully-protected" sealing feature. Choose from industry's most complete line of pillow blocks, flange, flange cartridge, cartridge, takeup and hanger blocks. Ask any one of the 40 Link-Belt offices for Data Book 2550.



Series 200 and 300 ball bearing blocks.

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Circle 510 on page 19

Park station wagons. A combined Neutral/Start button takes the car out of any previous gear position and starts the motor. A safety electrical sensing device prevents engagement of the reverse gears even if the reverse button is pushed accidentally above 10 mph.

## CONTINENTAL

Outward appearance of the 1957 Continental Mark II is virtually identical to the 1956 model. Four new iridescent colors are offered. As previously, 14 single shades and 5 two-tone combinations are available.

Mechanical changes in the car have been made to add power and improve acceleration. Compression ratio has been increased to 10 to 1 by redesign of the combustion chambers and reshaping of the pistons. A new carburetor has larger volume float bowls. The transmission uses a steel torque converter having a smaller diameter than the aluminum one previously used. Brake linings have been improved, and modified power steering control springs reduce effort required for steering. The car has a 40-amp generator.

**Engine Specifications**

| | |
|---|---|
| Type | OHV, Vee |
| No. cyls | 8 |
| Bore & stroke (in.) | 4.00 x 3.66 |
| Displ. (cu in.) | 368 |
| Comp. ratio | 10 to 1 |
| Bhp, max | * |

* Not available.

**Size and Weight**

| | |
|---|---|
| Wheelbase (in.) | 126 |
| Length (in.) | 218.4 |
| Width (in.) | 77.5 |
| Height (in.) | 56 |
| Weight (lb) | 4797 |

A limited-slip differential checks wheel spinning and sudden shock loads over uneven roads and under conditions when one wheel leaves the surface of the road or has poor traction.

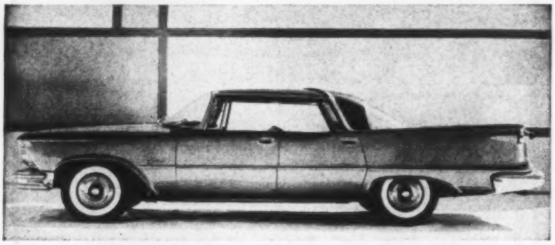
A self-regulating electric clock is new on the 1957 Continental, and an automatic headlight dimmer is available as an accessory. The optional air conditioning system has been redesigned to place the intake in the front end rather than in the leading edges of the rear quarter panels. Air now comes from the fresh-air duct in the engine compartment. Roof registers at each of the four passenger locations may be adjusted individually to control amount of incoming air and direction of flow.

## IMPERIAL

Chrysler's luxury automobile, the Imperial, is available in four series for 1957. The Imperial series consists of a four-door sedan and two and four-door hardtops. To these body styles the Crown series adds a convertible coupe—the first Imperial convertible made since 1951. The remainder of the line is comprised of the LeBaron, a four-door sedan, and the Imperial Limousine.

Styling features include longer, lower lines with more head room and leg room than last year's models provided; dual headlights, which are optional in states where legal; a four-way wraparound windshield; and curved glass in the side windows. Hardtops have large, sloping wraparound rear windows. The rear deck is low and slopes downward between outward-canted tail fins. A molded spare tire impression in the deck lid is optional.

A six-way power seat is standard on the LeBaron and Crown series, optional on the Imperial series. Standard equipment on all series includes TorqueFlite transmission, power steering, power brakes, power radio antenna, foot-operated parking brake, and dual exhausts. Front suspension is ball-joint, torsion-bar type, and the cars ride on low-pressure, 14-in. tires.



**Engine Specifications**

| | |
|---|---|
| Type | OHV, Vee |
| No. cyls | 8 |
| Bore & stroke (in.) | 4.0 x 3.9 |
| Displ. (cu in.) | 392 |
| Comp. ratio | 9.25 to 1 |
| Bhp, max | 325 |
| Torque, max (lb-ft) | 430 @ 2800 |

**Size and Weight**

| | |
|---|---|
| Wheelbase (in.) | 129.0 |
| Length (in.) | 224.0 |
| Width (in.) | 81.2 |
| Height (in.) | 56.7 |
| Weight (lb) | 4640 |

The TorqueFlite transmission, which was introduced in the 1956 model year, combines a high-performance torque converter with an automatic three-speed planetary gear box. Transmission control is through a five-button panel to the left of the steering column.

## Machine Tool Industry Grows Faster Than Nation's Economy

CHICAGO, ILL. — Production of new machine tools has increased twice as fast as the gross national product in the past five years. This was the recent observation of Louis Polk, president of the National Machine Tool Builders' Association.

Mr. Polk said that machine tool builders have nearly tripled their annual volume of shipments from $305 million in 1950 to $860 million five years later. In the same period, gross national product has increased about 1½ times.

Surveys show that metalworking industries served by the machine tool industry will expand 20 per cent by 1960 and another 20 per cent by 1965.

"No matter how our country's growth is projected," Mr. Polk said, "whether in terms of aircraft, new highways or TV sets and other consumer or durable goods, these products will only be produced by and flow from machine tools."

## Heat Radiation To Help Enable High Speed Flight

SAN FRANCISCO, CALIF. — An aircraft of the future passing through the sky at eight times the speed of sound will glow red and radiate enough heat for 400 average size homes. This was the recent prediction of Maury Sulkin, chief thermodynamicist for North American Aviation Inc.

At 5000 mph, Mr. Sulkin said, the plane would be subjected to temperatures of 6000 F were it not radiating enough of its own heat to reduce its skin temperature to 800 F.

"Up to now little consideration has been given to this phenomenon — equilibrium temperature. This has made the so-called thermal barrier into a mysterious obstacle that appeared impossible to hurdle. Actually it's not a true barrier at all, but a steep uphill climb."

Mr. Sulkin proposed establish-

(*Continued on Page* 22)

DRAFTING TRENDS

*A good cameraman is one key to making high quality cloth reproductions.*

Cloth reproductions safeguard originals, save drafting time

Many priceless original drawings are subjected to constant punishment. Corners become dog-eared (from filing and handling) and base stock is abused through repeated erasures when elements must be redrawn. In addition, drawings are prematurely aged and discolored as they go through a reproduction machine time after time.

An increasing number of plants are turning to reproductions on durable cloth stock to protect original drawings. The cloth repro is actually a "duplicate original." It can be repeatedly erased, corrected, intensified, redrawn, used for further printmaking. Negatives can be assembled with sections from other drawings. Expensive original drawings can thus be permanently and safely stored.

How photography improves worn original drawings

Since one method of producing a cloth reproduction is via photography, good camera work improves original drawings in several ways. Weak, fuzzy lines are intensified. Differences in strength of lines are often equalized. Faded or weak areas can be strengthened.

Even *after* an original drawing has been photographed, it can still be improved. A good retoucher can bring back parts of the original drawing. Background smudges or tape marks can be blocked out to give good, clear, clean prints.

By using photographic techniques, cloth repros can be *better than the original.*

Cloth repros simplify enlarging, reducing

*Photographic* enlargement or reduction to scale eliminates much routine work. By turning details over to the camera and an experienced staff, draftsmen are released for more important layout and design work. Often in a matter of one or two days, you can have a drawing enlarged or reduced to the desired size on a cloth base *without losing valuable drafting time.*

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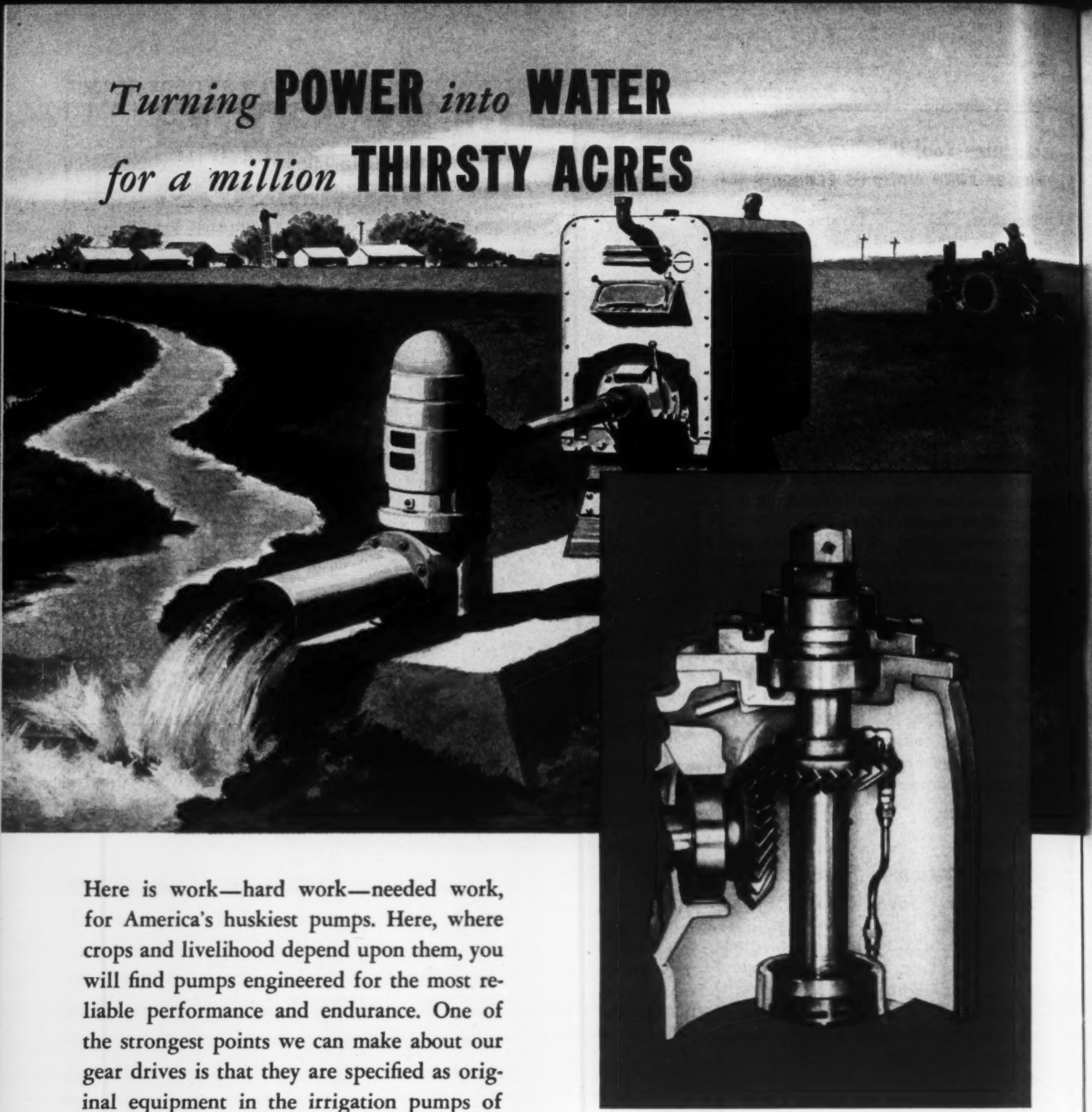
Circle 511 on page 19

*Turning* **POWER** *into* **WATER**
*for a million* **THIRSTY ACRES**



Here is work—hard work—needed work, for America's huskiest pumps. Here, where crops and livelihood depend upon them, you will find pumps engineered for the most reliable performance and endurance. One of the strongest points we can make about our gear drives is that they are specified as original equipment in the irrigation pumps of many manufacturers.

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Circle 512 on page 19

MACHINE DESIGN
READER SERVICE

# Reader Information Service

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## *for More Information . . .*

**CIRCLE ITEM NUMBERS**—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

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**MACHINE DESIGN**
**DEC. 13, 1956**

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| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 401 | 426 | 451 | 476 | 501 | 526 | 551 | 576 | 601 | 626 | 651 | 676 | 701 | 726 | 751 |
| 402 | 427 | 452 | 477 | 502 | 527 | 552 | 577 | 602 | 627 | 652 | 677 | 702 | 727 | 752 |
| 403 | 428 | 453 | 478 | 503 | 528 | 553 | 578 | 603 | 628 | 653 | 678 | 703 | 728 | 753 |
| 404 | 429 | 454 | 479 | 504 | 529 | 554 | 579 | 604 | 629 | 654 | 679 | 704 | 729 | 754 |
| 405 | 430 | 455 | 480 | 505 | 530 | 555 | 580 | 605 | 630 | 655 | 680 | 705 | 730 | 755 |
| 406 | 431 | 456 | 481 | 506 | 531 | 556 | 581 | 606 | 631 | 656 | 681 | 706 | 731 | 756 |
| 407 | 432 | 457 | 482 | 507 | 532 | 557 | 582 | 607 | 632 | 657 | 682 | 707 | 732 | 757 |
| 408 | 433 | 458 | 483 | 508 | 533 | 558 | 583 | 608 | 633 | 658 | 683 | 708 | 733 | 758 |
| 409 | 434 | 459 | 484 | 509 | 534 | 559 | 584 | 609 | 634 | 659 | 684 | 709 | 734 | 759 |
| 410 | 435 | 460 | 485 | 510 | 535 | 560 | 585 | 610 | 635 | 660 | 685 | 710 | 735 | 760 |
| 411 | 436 | 461 | 486 | 511 | 536 | 561 | 586 | 611 | 636 | 661 | 686 | 711 | 736 | 761 |
| 412 | 437 | 462 | 487 | 512 | 537 | 562 | 587 | 612 | 637 | 662 | 687 | 712 | 737 | 762 |
| 413 | 438 | 463 | 488 | 513 | 538 | 563 | 588 | 613 | 638 | 663 | 688 | 713 | 738 | 763 |
| 414 | 439 | 464 | 489 | 514 | 539 | 564 | 589 | 614 | 639 | 664 | 689 | 714 | 739 | 764 |
| 415 | 440 | 465 | 490 | 515 | 540 | 565 | 590 | 615 | 640 | 665 | 690 | 715 | 740 | 765 |
| 416 | 441 | 466 | 491 | 516 | 541 | 566 | 591 | 616 | 641 | 666 | 691 | 716 | 741 | 766 |
| 417 | 442 | 467 | 492 | 517 | 542 | 567 | 592 | 617 | 642 | 667 | 692 | 717 | 742 | 767 |
| 418 | 443 | 468 | 493 | 518 | 543 | 568 | 593 | 618 | 643 | 668 | 693 | 718 | 743 | 768 |
| 419 | 444 | 469 | 494 | 519 | 544 | 569 | 594 | 619 | 644 | 669 | 694 | 719 | 744 | 769 |
| 420 | 445 | 470 | 495 | 520 | 545 | 570 | 595 | 620 | 645 | 670 | 695 | 720 | 745 | 770 |
| 421 | 446 | 471 | 496 | 521 | 546 | 571 | 596 | 621 | 646 | 671 | 696 | 721 | 746 | 771 |
| 422 | 447 | 472 | 497 | 522 | 547 | 572 | 597 | 622 | 647 | 672 | 697 | 722 | 747 | 772 |
| 423 | 448 | 473 | 498 | 523 | 548 | 573 | 598 | 623 | 648 | 673 | 698 | 723 | 748 | 773 |
| 424 | 449 | 474 | 499 | 524 | 549 | 574 | 599 | 624 | 649 | 674 | 699 | 724 | 749 | 774 |
| 425 | 450 | 475 | 500 | 525 | 550 | 575 | 600 | 625 | 650 | 675 | 700 | 725 | 750 | 775 |

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**CARD INVALID WITHOUT COMPANY NAME—TYPE OR PRINT**

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| 401 | 426 | 451 | 476 | 501 | 526 | 551 | 576 | 601 | 626 | 651 | 676 | 701 | 726 | 751 |
| 402 | 427 | 452 | 477 | 502 | 527 | 552 | 577 | 602 | 627 | 652 | 677 | 702 | 727 | 752 |
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| 418 | 443 | 468 | 493 | 518 | 543 | 568 | 593 | 618 | 643 | 668 | 693 | 718 | 743 | 768 |
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| 420 | 445 | 470 | 495 | 520 | 545 | 570 | 595 | 620 | 645 | 670 | 695 | 720 | 745 | 770 |
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FIRST CLASS
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No Postage Stamp Necessary if Mailed in the United States

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IF EXTREME ACCURACY IS IMPORTANT . . IT'S A JOB FOR

G.S. GEARING

Here at G.S., 40 years of specialization and research have resulted in a degree of accuracy *you never thought possible* in the mass production of Small Gearing. If your needs call for hundreds or thousands, however simple or intricate, you'll get Gearing that meets the most exacting specifications, *in every piece we ship.* ★ Think of the assembly costs that cuts . . the increased production . . the smoother, quieter performance . . the greater satisfaction of users . . the greater profit to yourself. ★ Let capable G.S. engineers recommend the ONE best and most economical application for the job. Send drawings or details today. There's no obligation.

SEND FOR FREE *6-page Small Gearing Guide. It describes 80 types and applications. Contains useful charts . . a valuable aid to anyone interested in Small Gearing. Use company letterhead, please. No obligation, of course. Write today!*

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SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS
OF FRACTIONAL HORSEPOWER GEARING

FRACTIONAL HORSEPOWER GEARING

*40 Years of Specializing in Small Gearing!*

Circle 513 on page 19

FILL OUT COUPON
FOR FACTS,
SAMPLES!

ALUMINUM COMPANY
OF AMERICA
2244-M Alcoa Bldg., Pittsburgh 19, Pa.

Gentlemen:
Please send complete specification data
and samples of your aluminum fasteners.

Name

Title

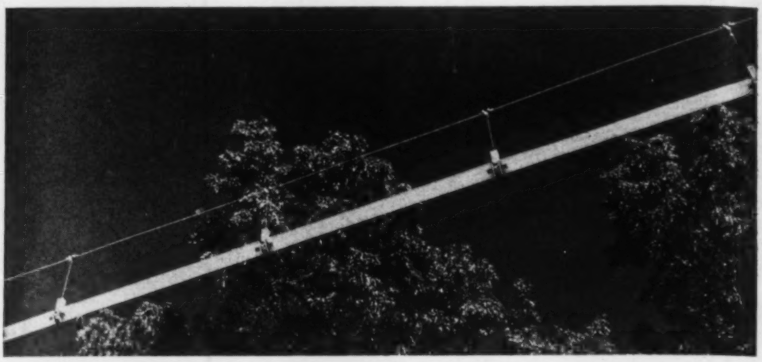
Company

Address

Always fasten aluminum with ALCOA® Aluminum Fasteners

available at your local ALCOA distributor

ALCOA ALUMINUM FASTENERS
ALUMINUM COMPANY OF AMERICA



UNIFORM HIGHWAY LIGHTING is the objective in this experimental installation of G-E fluorescent luminaires. A continuous row is parallel to the curb, 25 ft above the pavement. Fluctuations in brightness and the consequent discomfort of night driving are claimed virtually eliminated.

(*Continued from Page* 15)

ment of a "Thermal Mach Number Spectrum" which divides the speed ranges of aircraft into areas in which problems of heat can best be examined. He said problems of the first speed range—up to Mach 2—offer little difficulty to the heat engineer.

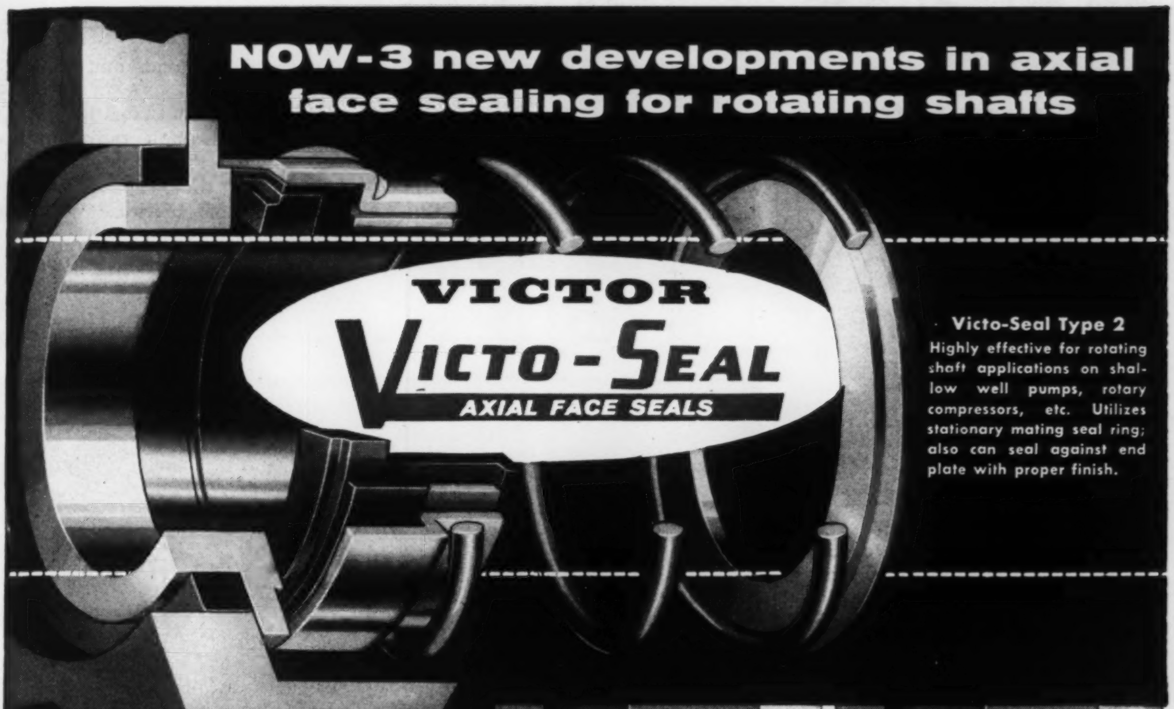
At speeds from Mach 2 to Mach 4 aerodynamic heating assumes great importance in aircraft design. "In the third or 'superthermantic' region—up to eight times the speed of sound—temperatures hotter than an acetylene flame will be reached."

"Above Mach 8 we may reach

MAN-SIZE SIX-SHOOTER is the "Ontos" track-laying hit-run weapon, first production models of which have been built by Allis-Chalmers and delivered to the Marine Corps. The Ontos mounts six 106-mm recoilless rifles, one 30-caliber machine gun and one 50-caliber spotting rifle which support the claim that it is more heavily armed than any other combat vehicle. Ontos carries a crew of three: driver, gunner and ammunition loader. With a six-cylinder, 145-hp, water-cooled engine, Ontos reaches 30 mph and climbs a 60 per cent grade. Total weight, combat loaded, is about 8½ tons.

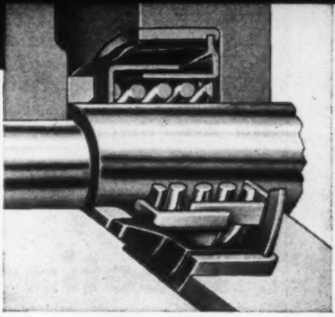
Circle 514 on page 19

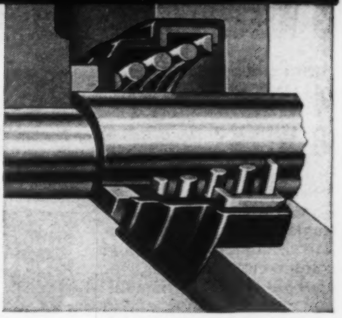
# NOW-3 new developments in axial face sealing for rotating shafts



**Victo-Seal Type 2**
Highly effective for rotating shaft applications on shallow well pumps, rotary compressors, etc. Utilizes stationary mating seal ring; also can seal against end plate with proper finish.

**Victo-Seal Type 3**
End face seal unit with metal O.D. for sealing against suitably finished mating surface. For press fit applications in pumps, machine tool applications, automotive equipment, etc., on shaft diameters of .312 to 1.000 in.





VICTOR
Victo-Seal

NEW
VICTOR
VICTO-SEAL

Now—water pumps and household appliances, automotive and other industrial equipment for handling fluids can all be sealed more securely and dependably than ever before.

New and exclusive Victo-Seal design—with Victoprene elastomer—assures it!

Victo-Seal incorporates the latest thinking in axial face shaft seal engineering. With the NEW positive torque lock, it eliminates diaphragm fatigue and maintains constant unitary function. Victo-Seal is self-aligning; it compensates automatically for wear, shaft movement and insulates against vibration. Its long-life compression spring provides controlled pressure contact between sealing surfaces.

What's more, each type Victo-Seal is a simple, self-contained unit—moderately priced, and easily and economically installed on the production line or in the field.

Literature available through your Victor Field Engineer, or on request to: Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill. In Canada: Victor Mfg. & Gasket Co. of Canada Ltd., St. Thomas, Ont.

**Victo-Seal Type 6**
A highly economical end face seal with Victoprene outside diameter assures ease of installation and removal. Metal parts are completely encased in and seal ring bonded to Victoprene diaphragm. Extensively used in the appliance industry.

**VICTOR**

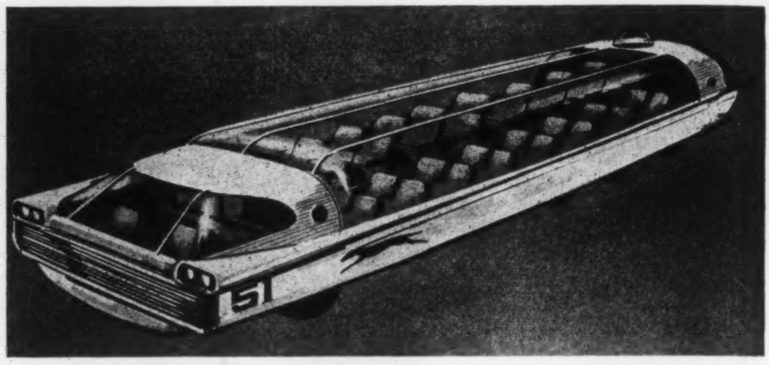
**Sealing Products *Exclusively***

**GASKETS • OIL SEALS • PACKINGS • MECHANICAL SEALS**

*Circle 515 on page 19*

a new barrier where air gets so hot it loses its identity as air. Perhaps we may not even be able to transmit radio or radar signals through this layer of air that would surround an airplane in flight. So far, temperatures in this area—above 6000 F—have only been exceeded by man in shock tube experiments, the manufacture of synthetic diamonds and nuclear detonations.

"If heat did not remove itself from metal through radiation to space, obviously the contemplation of flight at these speeds would stagger the imagination. While it presents the engineer with a great many problems it does not appear impossible."



BUS OF THE FUTURE may look like this artist's version as early as 1966. According to Greyhound Lines, future models will feature passenger television sets, a raised deck, a special tinted roof, men's and women's lavatories, an observation dome, special baggage compartments, fog-piercing headlights, rear view television for the driver, and an airplane-like ramp at the rear.

## Meetings

### AND EXPOSITIONS

**Jan. 14-16—**

**Third National Symposium on Reliability and Quality Control in Electronics** to be held at the Hotel Statler, Washington, D. C. Sponsors are Institute of Radio Engineers, American Society for Quality Control, American Institute of Electrical Engineers and Radio-Electronic-Television Manufacturers Association. Further data are available from Mr. R. G. Murrell, Melpar Inc., Falls Church, Va.

**Jan. 14-18—**

**Society of Automotive Engineers Inc.** Annual Meeting to be held at the Sheraton-Cadillac and Statler Hotels, Detroit. Further information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

**Jan. 16-18—**

**Society of Plastics Engineers Inc.** Thirteenth Annual National Technical Conference to be held at the Hotel Sheraton-Jefferson, St. Louis. Further information can be obtained from society headquarters, 34 E. Putnam Ave., Greenwich, Conn.

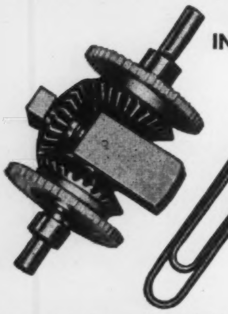
**Jan. 21-25—**

**American Institute of Electrical Engineers.** Winter General Meeting to be held at the Hotel Statler, New York. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

**Jan. 28-31—**

**Plant Maintenance and Engineering Show** to be held at the Cleveland Public Auditorium. Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

ON THE SHELF!
SINGLE SPIDER GEAR DIFFERENTIALS
by FORD INSTRUMENT



AVAILABLE IN FOUR SIZES:
1/8", 3/16", 1/4", and 5/16" Shaft Diameters

NOTE! Prices of 1/8" units have been drastically reduced.

GUARANTEED SHIPMENT WITHIN:

(WITHOUT END GEARS) TYPE
1 WEEK for units with set shaft lengths* A
3 WEEKS for units with shaft lengths to customer specs B
(WITH END GEARS)
4 WEEKS for units with stock end gears C
8 WEEKS for units with end gears to customer specs D
(SUBJECT TO PRIOR SALE)
*Note: 5/16" units are not stocked with set shaft lengths.

Ford Instrument produces single spider gear differentials to highest military and commercial standards, for *extreme accuracy* in addition and subtraction, and in servo loop applications. Seven ways superior. Call or wire W. Mohr, Component Sales Division (STillwell 4-9000) for prices, or check and mail coupon below, stating quantity. Data bulletin with performance curves and characteristics will be sent with the prices.

Component Sales Division MD
FORD INSTRUMENT COMPANY
DIVISION OF SPERRY RAND CORPORATION
31-10 Thomson Avenue, Long Island City 1, N. Y.

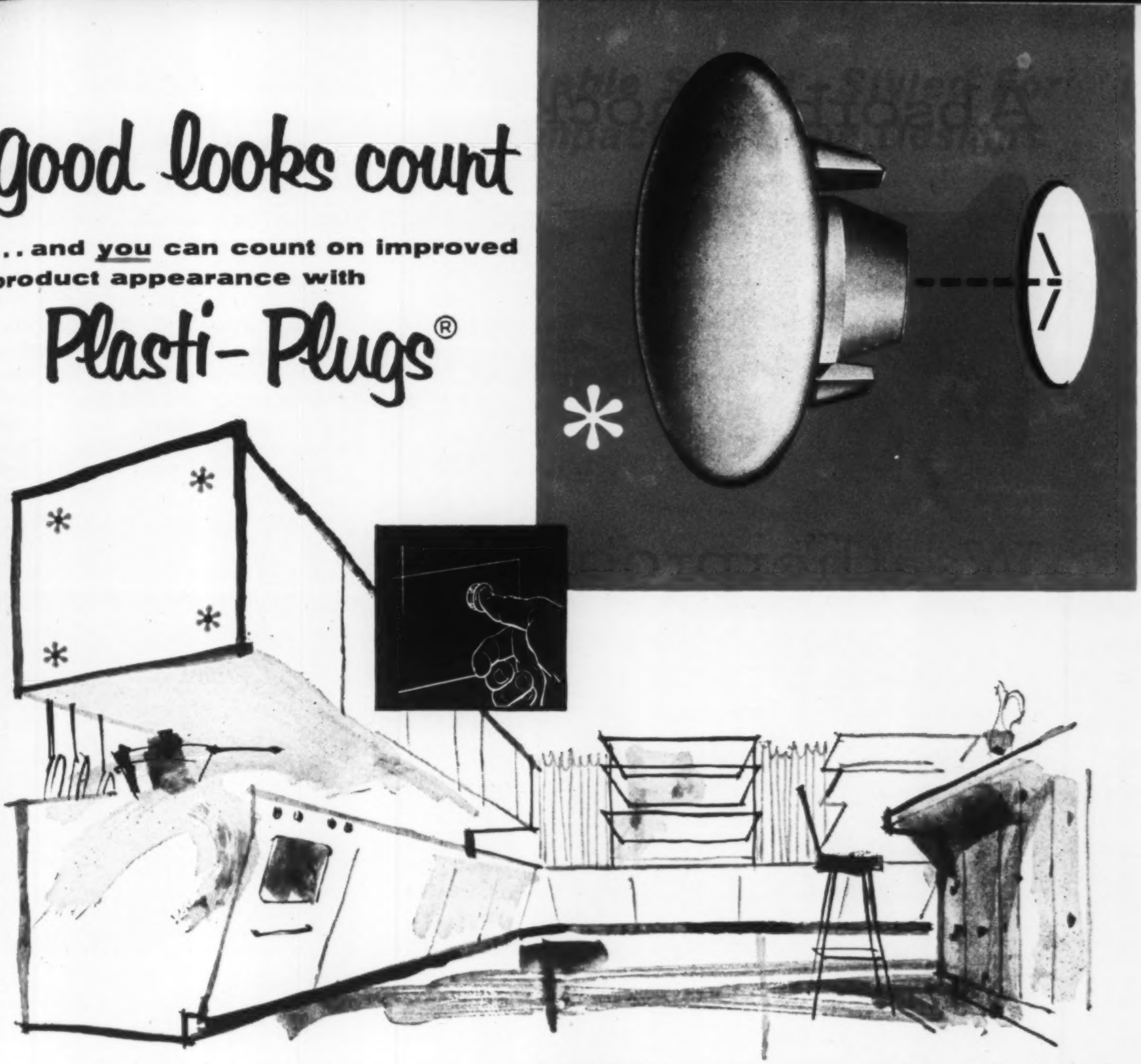
Please send me prices on the following:
Circle size of unit desired:
1/8" 3/16" 1/4" 5/16"
Circle category for type of units needed: (Check two if both apply)
A B C D
I want ________ (number) units:
Name________
Position________
Company________
Street________
City________ State________

Circle 516 on page 19

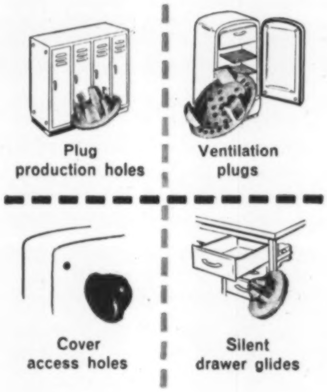
# good looks count

**... and you can count on improved product appearance with**

# Plasti-Plugs®



Metal kitchen cabinets with unsightly production holes showing? Not if Fastex Plasti-Plugs (one piece, self-retaining hole plugs) are used! Snapping-in with a light touch of the finger, Plasti-Plugs are available in 45 standard sizes, in colors to match every product. Low in cost to buy and apply, Plasti-Plugs do double duty too—can be used for dust protection, friction glides and as replaceable plugs. Special moisture-sealing plugs may also be had. Made of polystyrene, nylon or vinyl, they're non-corrosive, always good-looking.



**FASTEX**

Trade Mark

195 Algonquin Road, Des Plaines, Illinois
**In Canada:** Canada Illinois Tools Limited, Toronto, Ontario

Plasti-Plugs

Write for free catalog.
**45 standard sizes**
listed . . . tells how easily you can "snap in" Plasti-Plugs by Fastex.

FASTEX
SHAKEPROOF
**DIVISIONS OF ILLINOIS TOOL WORKS**

*Circle 517 on page 19*

Absorbs shocks

Weatherproofs

Seals

**Armstrong DK-153** is a resilient cork-and-sponged-rubber composition backed with pressure-sensitive adhesive. It is a versatile material being used in hundreds of different ways in industry . . . as a shock absorber for record player lids, to keep air and rain from seeping in around skylights and ceiling domes, to seal dust and lint out of motor control boxes. You can get DK-153 in die-cut shapes, rolls, strips or sheets, and in 1/32″, 1/16″, 3/32″, and 1/8″ thicknesses. In any form, DK-153 is easy to apply; just peel off its protective covering and press into place. For samples, write Armstrong Cork Company, Industrial Division, 7312 Dean Street, Lancaster, Pennsylvania.

**Armstrong DK-153**

*. . . used wherever performance counts*

*Circle 518 on page 19*

# MEN

## OF MACHINES

Announcement of the appointment of **R. J. Lindsey** to vice president in charge of engineering has been made by the Hydraulic Press Mfg. Co., Mt. Gilead, O. He was director of engineering. Mr. Lindsey joined the company in 1940 and subsequently served as assistant chief engineer and chief design engineer. From 1950 to 1955 he was chief engineer of Elmes Engineering Div. of American Steel Foundries. He then returned to H-P-M as director of engineering.

R. J. Lindsey

**Francis A. Noll** has been appointed director of engineering by Amana Refrigeration Inc., Amana, Iowa. Mr. Noll, who joined Amana a year ago as chief cabinet engineer, has been engaged in household refrigeration engineering work for nine years.

**Jesse Stitzer** has been appointed chief engineer of the Beta Electric Div. of Sorenson & Co., Inc., New York. Mr. Stitzer joined the division in 1950 in the test laboratory, then moved to the design division. He has served as a project engineer for the last three years. Mr. Stitzer replaces **Dr. Victor Wouk,**

who has been made general manager and engineering director.

**Thomas F. Marlow** has been appointed vice president in charge of engineering by the Standard Tube Co., Detroit.

A controls division has been established by Tipp Mfg. Co., Tipp City, O., for the purpose of producing a diversified line of packaged industrial controls. **R. A. Moenich** was named chief engineer of the division.

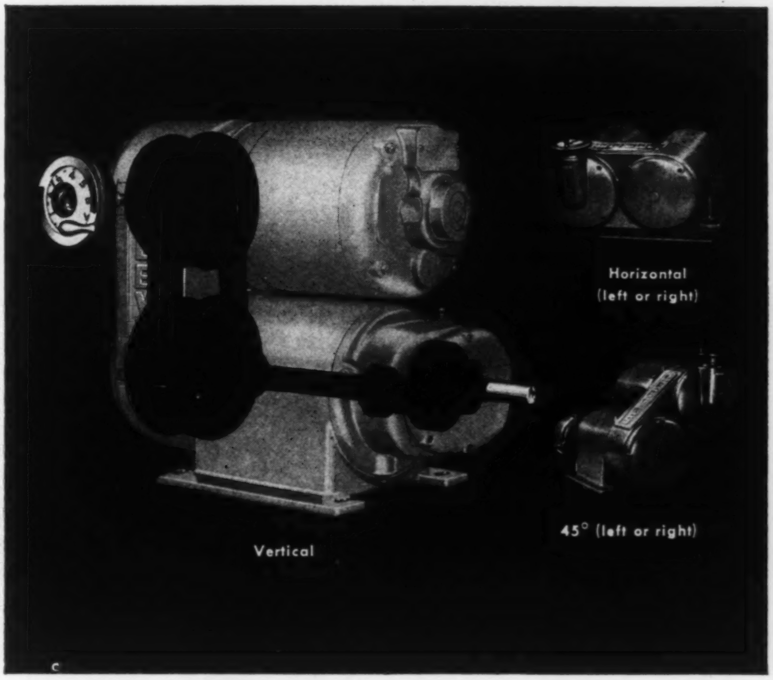
Mixing Equipment Co. Inc., Rochester, N. Y., has promoted **Richard D. Boutros** to vice president and director of engineering. He joined the company's engineering staff in 1946 and has been chief engineer since 1949.

Richard D. Boutros

**Milton Dykman** succeeds Mr. Boutros as chief engineer. Mr. Dykman also joined the firm in 1946; he has been assistant chief engineer since 1951. **Howard C. Shufelt** was named assistant to the chief engineer. He has been with the company since February 1955.

**Joseph A. Despres** has been appointed administrative assistant to the vice president for engineering at Ford Instrument Co., Long Island City, N. Y. Mr. Despres was associated with Bernard Rice's Sons Inc. for 20 years; for 13

Variable Speed – Styled For Compact Machine Designs

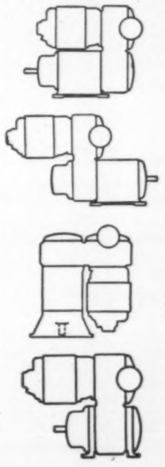


REEVES

FRACTIONAL Vari-Speed MOTODRIVE

WHERE DO YOU NEED THE OUTPUT SHAFT?

Motor side, control side, or vertical down



▶ REEVES fractional hp. Motodrive is a complete power package, engineered in over 100 assemblies to fit wherever your design calls for variable speed.

Choose from vertical, 45° or horizontal models in ¼ to 1 hp. . . . get stepless accurate speeds—within a 2:1 to 10:1 range—from as low as 3 rpm to a maximum of 4660 rpm.

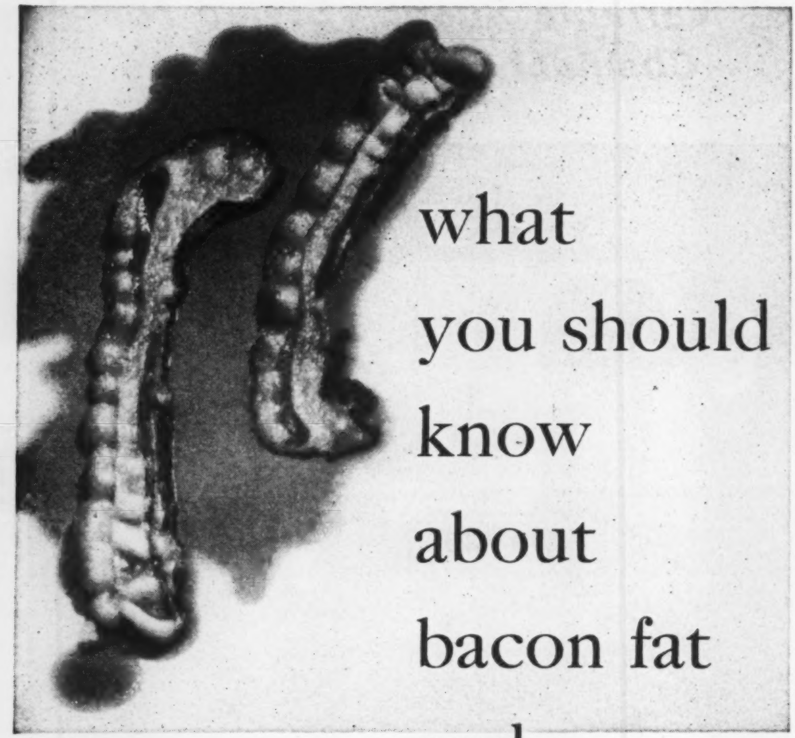
Available in standard, weather resistant, totally enclosed or splash-proof enclosures; full range of manual or automatic controls.

REEVES Motodrive—the *right* speed for *every* need . . . in *any* place.

Write Dept. H23b-M543 for ratings and dimensions.

REEVES PULLEY COMPANY
Division of RELIANCE ELECTRIC AND ENGINEERING CO.
Columbus, Indiana

Circle 519 on page 19



what you should know about bacon fat and Albanene

**Here's the buying information you should have to get the *best* value when you buy tracing paper.**

1. **The usual way** of "transparentizing" tracing papers is with waxes or mineral oils—much the way bacon fat makes a paper towel transparent. Eventually, these oily fluids "leak" out—leaving the paper opaque and useless for reproductions.

   **Result:** Valuable drawings on ordinary tracing papers eventually become yellow or brittle—lose their reproduction qualities. And, these days, replacements often cost twice as much as the originals.

2. **The K & E way**—Albanene tracing paper is made transparent with an inert synthetic resin which is chemically stable . . . can't leak out—ever!

   **Result:** Albanene stays transparent . . . stays strong . . . protects every nickel you invest in time and talent working on it.

   **Important:** During manufacture, constant testing *guarantees* uniformity as well as pencil taking and erasing qualities. The very qualities that have made Albanene—America's best selling tracing paper.

**Try Albanene Today** . . . it's available in 3 weights and in rolls, sheets or pads. Try it now . . . it's the best value you can buy!

**89 YEARS OF LEADERSHIP**

In equipment and materials for drafting, surveying, reproduction and optical tooling . . . in slide rules and measuring tapes.

**KEUFFEL & ESSER CO.**
NEW YORK • HOBOKEN, N. J. • Detroit • Chicago • St. Louis • Dallas • San Francisco • Los Angeles
Seattle • Montreal

years he was president and chief engineer. He served for four years as administrative assistant to the director of the engineering and production division of Airborne Instruments Laboratory Inc.

**Earl L. Steele** recently was named chief development engineer of the Device Development Dept. in the Semiconductor Products Div. of Motorola Inc., Chicago. Dr. Steele's headquarters will be in Phoenix, Ariz.

**Charles E. Rees Jr.** was recently named assistant to the president, engineering, by Gladden Products Corp., Glendale, Calif. He will be in charge of all special engineering projects for the various divisions of the corporation. He will also serve in an advisory capacity for current engineering and manufacturing projects. Mr. Rees joined Gladden in 1951 as chief engineer.

Charles E. Rees Jr.

Hyster Co., Portland, Ore., recently announced several changes in its engineering organization. **Robert C. Shoemaker,** supervising engineer of Construction Machinery for 12 years has been promoted to the position of supervising engineer, patents and product analysis. **T. Richard Hazel,** supervising engineer of the Tractor Equipment Div. for three years, has now been assigned the added responsibilities of supervising the Construction

*Circle 520 on page 19*

Machinery design section. **Ronald A. Johnson,** supervising engineer in charge of the Standards Div., has now been assigned the I.B.M. engineering and catalog files.

**Everett E. Christensen** has been appointed assistant flight test division engineer for Lockheed's Missile Systems division, Van Nuys, Calif. For the last two and a half years Mr. Christensen has been base manager of the missile division's flight test facilities at Holloman Air Development Center, Alamogordo, N. M.

**Rod Koutnik** recently joined the Automatic Controls Div. of Clary Corp., San Gabriel, Calif.

**S. Sydney Minault** has been appointed vice president of National Research Corp., Cambridge, Mass. He joined this organization in 1953 and has served as general manager of the equipment division for the past two years. He has been associated with Sperry Gyroscope Co., the Ansco Div. of General Aniline & Film Corp. and Tracerlab Inc.

**Leonard L. Johnson** has been promoted to senior research engineer at Armour Research Foundation of Illinois Institute of Technology, Chicago.

Appointment of **Allan W. Jayne** as director of research has been announced by the Electronics Div. of the Gabriel Co., Needham Heights, Mass.

**William Rainey** has been appointed manager of new product development for W-S Fittings Div., H. K. Porter Co. Inc., Roselle, N. J. Mr. Rainey was previously an air conditioning engineer and contractor. He had also been associated with Orr and Sembower Co. of Pennsylvania and American Chain and Cable Co.

Appointment of **Clarence G. Bauer** as manager of quality control has been made by the Stamping Div. of Chrysler Corp., Detroit. He has been associated with the company since 1931.

Norgren SPRAY-LUBE

INCREASES PRODUCTION from MACHINE TOOLS

- Increases Tool Life
- Improves Quality of Work
- Reduces Maintenance Costs

Metal Cutting Saw

CUTS FASTER... DOESN'T OVERHEAT
Oliver Sawing Machine cuts 4" to 6" slabs of non-ferrous metals. By changing to SPRAY-LUBE: (1) Fusion of chips to saw teeth ended. (2) No galling—surfaces now resemble machined finish. (3) Saw feed faster—cuts 6" aluminum slabs at 5 fpm.

Punch Press

OUTPUT INCREASED 15% DIE LIFE INCREASED 100%
Formerly lubricated by hand swabbing every 6 cycles of press, splashing on machine, floor and operator. Now, SPRAY-LUBE automatically lubricates die and blank every cycle, increasing die life 100% and output 15%. Lubricant cost cut in half.

Tapping Machine

30% MORE OUTPUT
SPRAY-LUBE replaced flood system on tapping machine at the Square D Company, eliminating excess of lubricant and ending time lost for cleaning parts. Splashing lubricant on operator and floor also ended. Production increased 30%.

Gear Hobbers

$250 A YEAR LUBRICANT SAVING PER MACHINE
Cullman Wheel Co. replaced splash coolant systems on gear hobbers with SPRAY-LUBE. Results: (1) Tool life increased. (2) Tool grinding time reduced. (3) Working conditions cleaner, safer. (4) $250 a year per machine saved in lubricant costs.

Turret Lathe

OUTPUT DOUBLED
SPRAY-LUBE on lathe at O.K. Rubber, Inc. has: (1) Increased surface cutting speed from 45 to 75 rpm, nearly doubling output of machine. (2) Ended welding of chips to tool. (3) Increased depth of cut. (4) Improved quality of work.

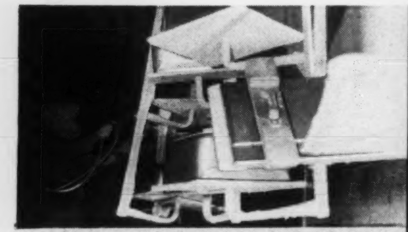
Chain Drive

OVER TWO TIMES LONGER CHAIN LIFE
At Wagner Electric in St. Louis, SPRAY-LUBE automatically lubricates chain drive on degreasing machine. Chain now runs smoothly and quietly. Lubricant, removed by the hot cleaning solution, is now constantly replaced, doubling chain life.

For complete information about Norgren SPRAY-LUBE, call your nearby Norgren Representative listed in your telephone directory—or WRITE THE FACTORY for Bulletin 537

C.A. Norgren CO.

C. A. NORGREN CO. 3442 So Elati St., Englewood, Colorado



Reynolds can paint entire parts a solid color, mask and paint or do paint filling in combination with mechanical finishing to supply practically any desired texture or highlighting effect.

Part of a battery of new high speed buffing equipment available at Reynolds. Scratch-brushing, satin finishing, highlighting, embossing and other mechanical finishes are also available.

Alodine system at Reynolds is adaptable to immersion, spray or brush type finishing. Etching, brightening and other chemical finish treatments are also available at Reynolds.

## for greater design freedom and finer "finished" aluminum products ...use the new, vastly expanded

# REYNOLDS

# FINISHING FACILITIES

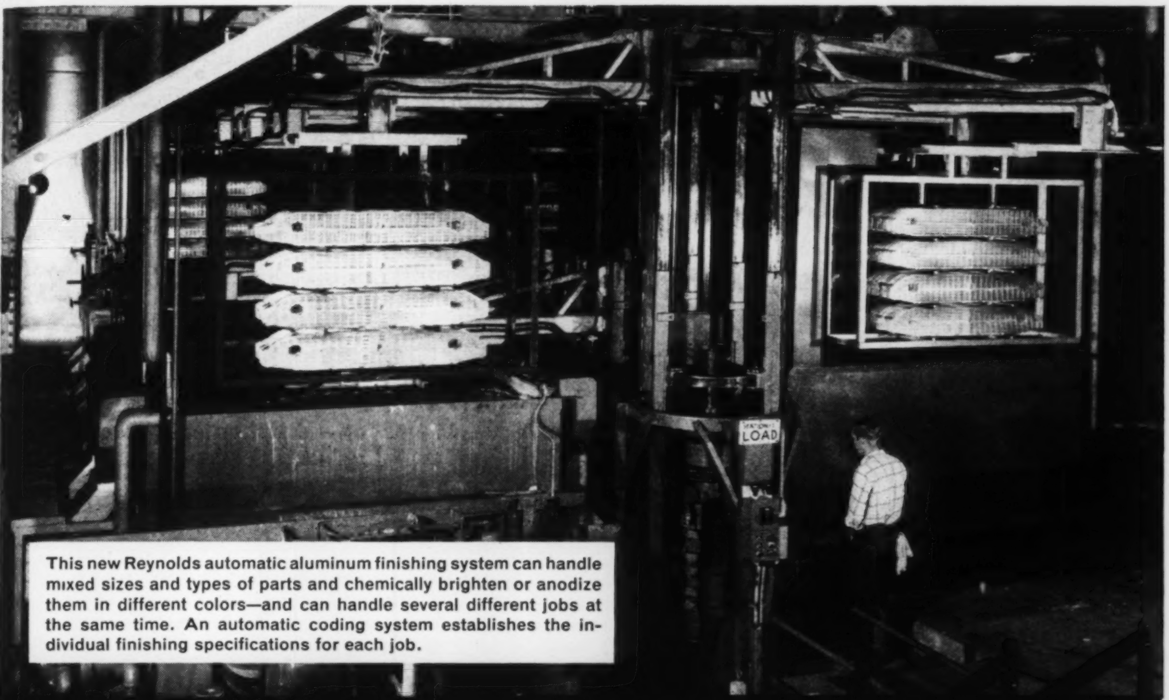
For the magic touch of gleaming clear and color anodized finishes—and for many types of mechanical, chemical and paint film finishes—you can depend on finishes from Reynolds to add sales appeal and value to the aluminum products you design.

Reynolds multi-million dollar investment in finishing equipment—some of this equipment illustrated on these pages—assures you the finest aluminum finishing facilities available anywhere. These recently expanded facilities permit new and greater flexibility in your design thinking. And these facilities are backed by Reynolds years of technical experience with practically every finishing process and technique applicable to aluminum plus Reynolds quality control from mine to finished part.

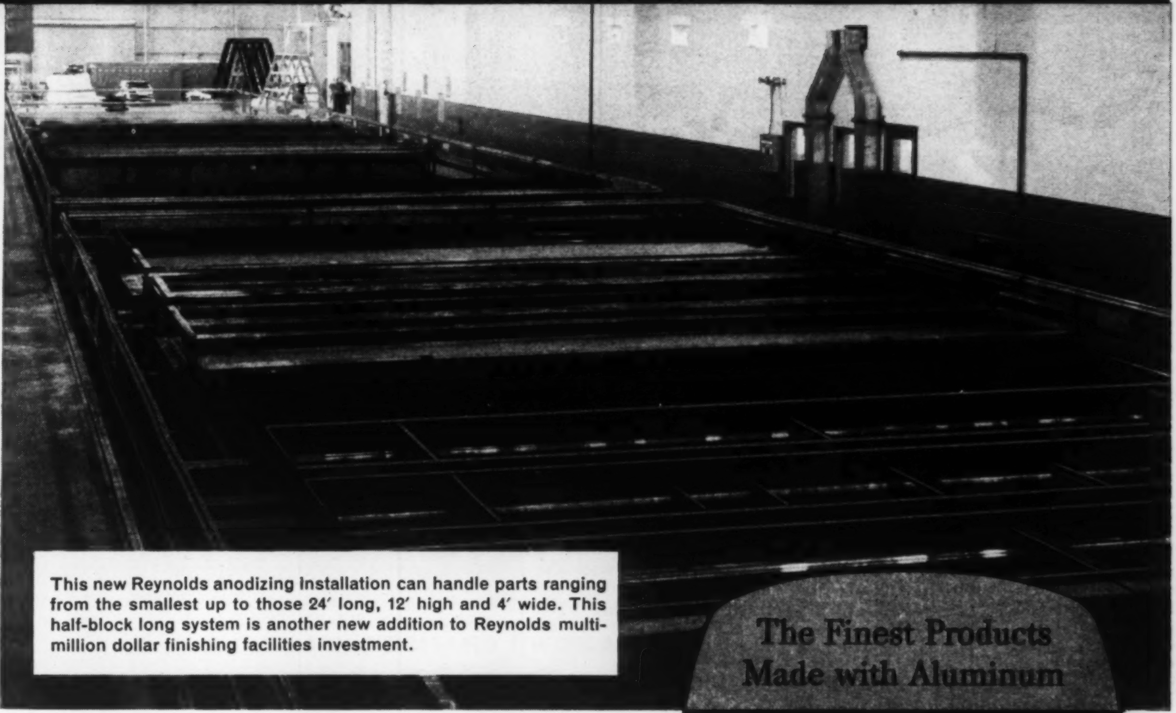
For full details on the finishing and fabricating facilities available, call the Reynolds Office listed under "Aluminum" in your classified telephone directory or write *Reynolds Aluminum Fabricating Service, 2061 South Ninth Street, Louisville 1, Ky.*

*See "CIRCUS BOY", Reynolds new dramatic series, Sundays on NBC-TV*

**REYNOLDS ALUMINUM**
**FABRICATING SERVICE**



This new Reynolds automatic aluminum finishing system can handle mixed sizes and types of parts and chemically brighten or anodize them in different colors—and can handle several different jobs at the same time. An automatic coding system establishes the individual finishing specifications for each job.



This new Reynolds anodizing installation can handle parts ranging from the smallest up to those 24′ long, 12′ high and 4′ wide. This half-block long system is another new addition to Reynolds multi-million dollar finishing facilities investment.

The Finest Products
Made with Aluminum
are made with
REYNOLDS ALUMINUM

**BLANKING · BRAZING · DRAWING · EMBOSSING**
**FINISHING · FORMING · RIVETING**
**ROLL SHAPING · TUBE BENDING · WELDING**

*Circle 522 on page 19*

## Pre-stressed Diamond Roller Chains pass highest lifting standards for Clark Equipment

**PRE-STRESSED**
Pre-stressing by Diamond brings pin-bushing seating into stabilized relationship prior to installation.

**SHOT-PEENING**
Link plates, rollers and other parts of Diamond Chains have been shot-peened since 1944 to increase fatigue resistance.

**UNIFORM CONSTRUCTION**
Specialized heat treating, manufacturing facilities and testing procedures guarantee uniform highest quality in every Diamond Chain.

Trade ◇® Mark

On leading makes of materials handling equipment, such as the Clarklift 40 illustrated, Diamond Roller Chain is first choice for lifting as well as for other power transmission requirements.

The reasons are clear. Diamond Roller Chains give more economical performance over a longer service life. Their extra high uniform quality means dependable, safe operation. Pre-stressing and other special manufacturing techniques increase Diamond Chains' ability to take rough treatment and minimize maintenance at the same time.

Your records will show that it pays to specify Diamond Chain for new equipment and for replacement. Look for the Diamond trade mark on the links.

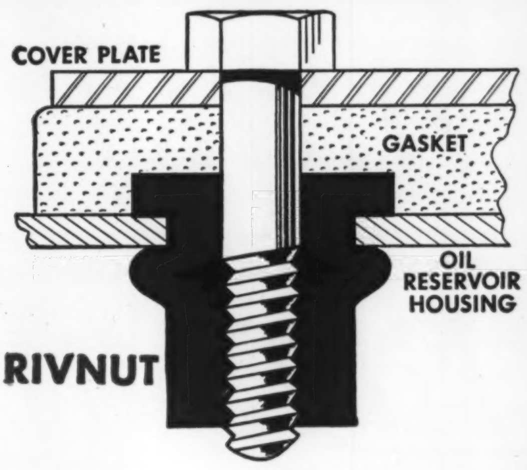
**DIAMOND CHAIN COMPANY, Inc.**
*Where High Quality is Traditional*
**Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana**
**Offices and Distributors in All Principal Cities**

**DIAMOND ROLLER CHAINS**

*Circle 523 on page 19*

# B.F.Goodrich RIVNUTS

## save time, cut costs by eliminating welding, tapping, cleaning



**OLD WAY**

1 Weld 4 nut plates to inside of housing
2 Drill
3 Tap
4 Clean
5 Attach cover with bolts

**WITH RIVNUTS**

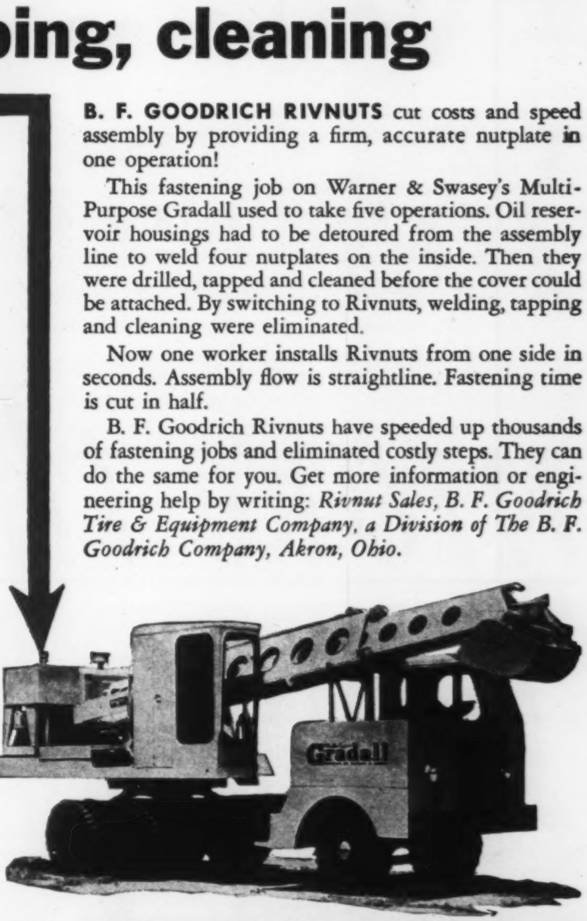
1 Punch holes in housing
2 Insert Rivnuts and upset
3 Attach cover with bolts

**B. F. GOODRICH RIVNUTS** cut costs and speed assembly by providing a firm, accurate nutplate in one operation!

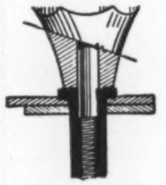
This fastening job on Warner & Swasey's Multi-Purpose Gradall used to take five operations. Oil reservoir housings had to be detoured from the assembly line to weld four nutplates on the inside. Then they were drilled, tapped and cleaned before the cover could be attached. By switching to Rivnuts, welding, tapping and cleaning were eliminated.

Now one worker installs Rivnuts from one side in seconds. Assembly flow is straightline. Fastening time is cut in half.

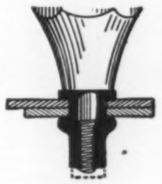
B. F. Goodrich Rivnuts have speeded up thousands of fastening jobs and eliminated costly steps. They can do the same for you. Get more information or engineering help by writing: *Rivnut Sales, B. F. Goodrich Tire & Equipment Company, a Division of The B. F. Goodrich Company, Akron, Ohio.*



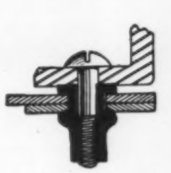
### HOW RIVNUTS PROVIDE AT LEAST 6 CLEAN THREADS IN ONE SIMPLE OPERATION:



**1 Rivnut is threaded onto pull-up stud of heading tool, then inserted.**



**2 Tool lever operates pull-up stud forming a bulge in the Rivnut shank.**



**3 After upset, Rivnut threads are still clean and intact, ready for screw attachment.**

# RIVNUT

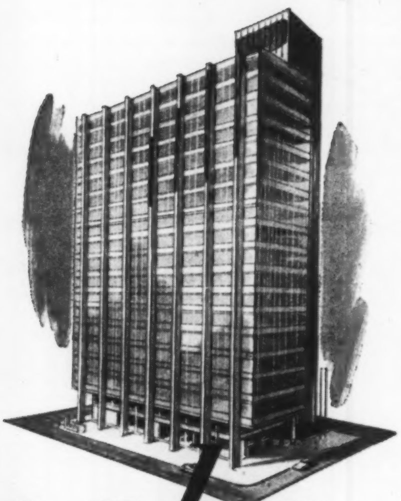
***THE ONLY ONE-PIECE BLIND RIVET WITH THREADS***

**SEND NOW FOR FREE RIVNUT DEMONSTRATOR**

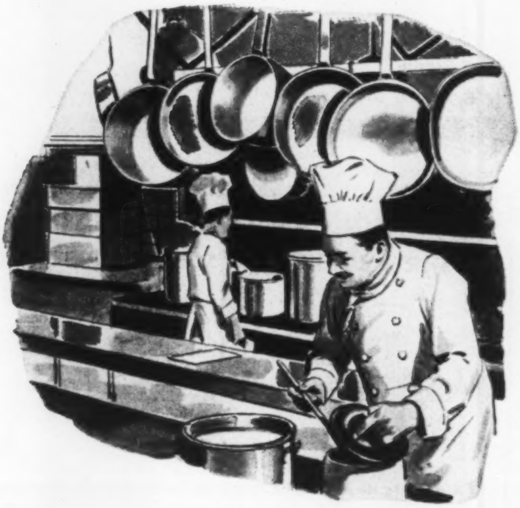
Demonstrates with motion how you can use Rivnuts to fasten WITH and TO. Explains construction, simplicity of installation. Get your free copy by writing to: The B. F. Goodrich Co., Dept. MD126, Akron, Ohio.

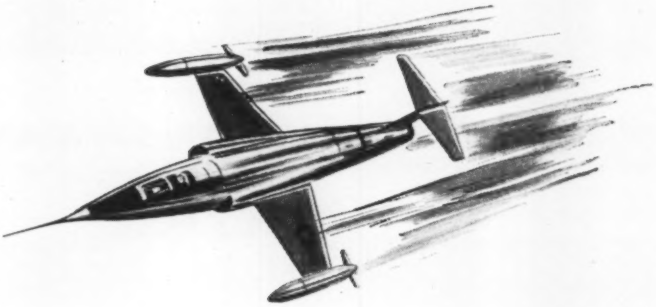
SEE HOW RIVNUTS WORK

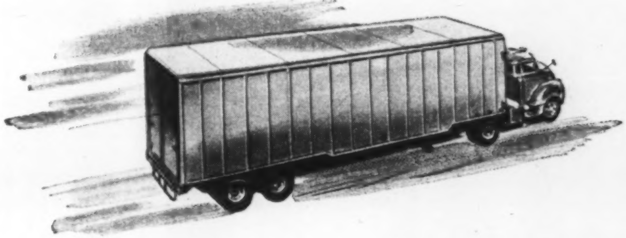
XUM



# *Now... You can make more things of*







# *Stainless Steel*

## The new "200" Series Stainless Steels successfully ease nickel shortage!

With the new low-nickel "200" Series Stainless Steels, producers can greatly expand their output of Chrome-Nickel stainless from existing nickel supplies. These steels provide practical, workable grades of stainless that can be applied to a wide variety of uses.

Made of Chromium-Nickel-Manganese—the "200" Series steels are helping to meet constantly growing needs in transportation, building, manufacturing and many other fields. They're becoming increasingly popular in kitchen utensils, appliances, truck bodies, trains, automobile trim, and scores of products for industrial, home and business use. For further information, see your stainless steel supplier, or write Electromet—leading producer of more than 100 alloys, including chromium and manganese, for the steel and non-ferrous metal industries.

**ELECTRO METALLURGICAL COMPANY**
*A Division of Union Carbide and Carbon Corporation*
**30 East 42nd Street** UCC **New York 17, N. Y.**

The term "Electromet" is a registered trade-mark of Union Carbide and Carbon Corporation

Electromet

***Metals do more all the time... Thanks to Alloys***

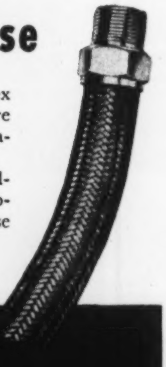
*Offices:* BIRMINGHAM • CHICAGO • CLEVELAND • DETROIT • LOS ANGELES • HOUSTON • PHILIPSBURG, N. J. • PITTSBURGH • SAN FRANCISCO

## Now... Local Availability on

## Titeflex
### Seal-Tight, Time-Saving
## Quick-Seal Couplings

Titeflex Couplings are *leakproof* at *all* operating pressures—the higher the pressure the tighter the seal! Couple or uncouple in ONE second... without the aid of tools. Straight-through or single or double check-valve types. Allow free flow of *any* viscous material. Sizes from ¼″ to 12″ diameter. Made from a variety of metals and alloys to suit innumerable industrial applications.

## Titeflex
## Flexible Metal Hose



—the ideal "conveying mate" for Titeflex Couplings. Withstands high temperature and pressure stresses. Impervious to vibration and corrosive action.

Both these time-tested products are available for immediate shipment from distributors' stocks in most areas. Otherwise write, wire or telephone direct.

CALL YOUR LOCAL
DISTRIBUTOR

Consult the
yellow pages
of your telephone directory

Your one source
for both
Hose and Couplings

**Titeflex**

TITEFLEX, INC., 508 HENDEE STREET, SPRINGFIELD 4, MASS.

Tapered for positive suspension.
High radial sealing surface.
"Tongue and groove" for easy installation.
Clearance for radial motion.

# KOPPERS HUHN CARBON RING

## Reduces Steam Loss as much as 90%!

The unique design of Koppers Huhn Carbon Ring reduces steam loss far below the customary 1% loss of labyrinths and carbon garter spring rings. Huhn Carbon Ring keeps steam loss as low as ¼ of 1% . . . often as little as 1/10 of 1%. Using your own figures for steam costs, you can easily discover how much Koppers Huhn Carbon Rings can save you annually.

The design assures you continuous radial sealing . . . because a radial sealing surface is always forced against a chamber wall. Automatic suspension . . . even during shutdowns . . . prevents shaft contact, reduces wear, and prolongs life. The Huhn Carbon Ring operates with peak efficiency at highest shaft surface speeds and highest operating temperatures.

Koppers Huhn Carbon Ring replaces labyrinths and carbon garter spring rings in compressors, and steam and water turbines. Steam savings alone often pay within a year for the cost of replacement. Discover now how Huhn Carbon Rings reduce steam and fluid losses and minimize operating, maintenance and repair costs. Write: KOPPERS COMPANY, INC., *Piston Ring and Seal Dept.*, 2312 Hamburg St., Baltimore 3, Md.

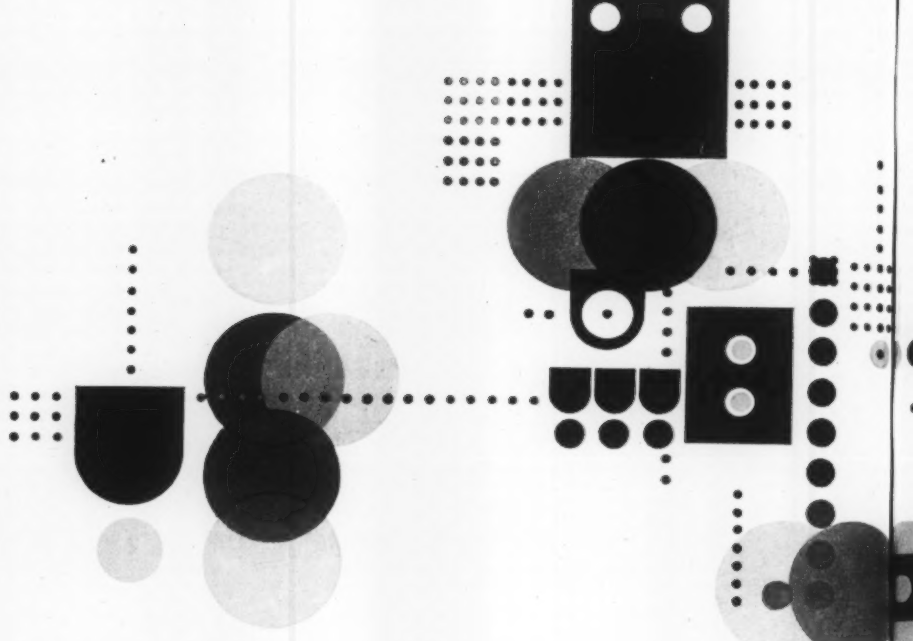
**Koppers Company, Inc.**
**Metal Products Division**
**Piston Ring and Seal Dept.**

**Engineered Products**
**Sold with Service**

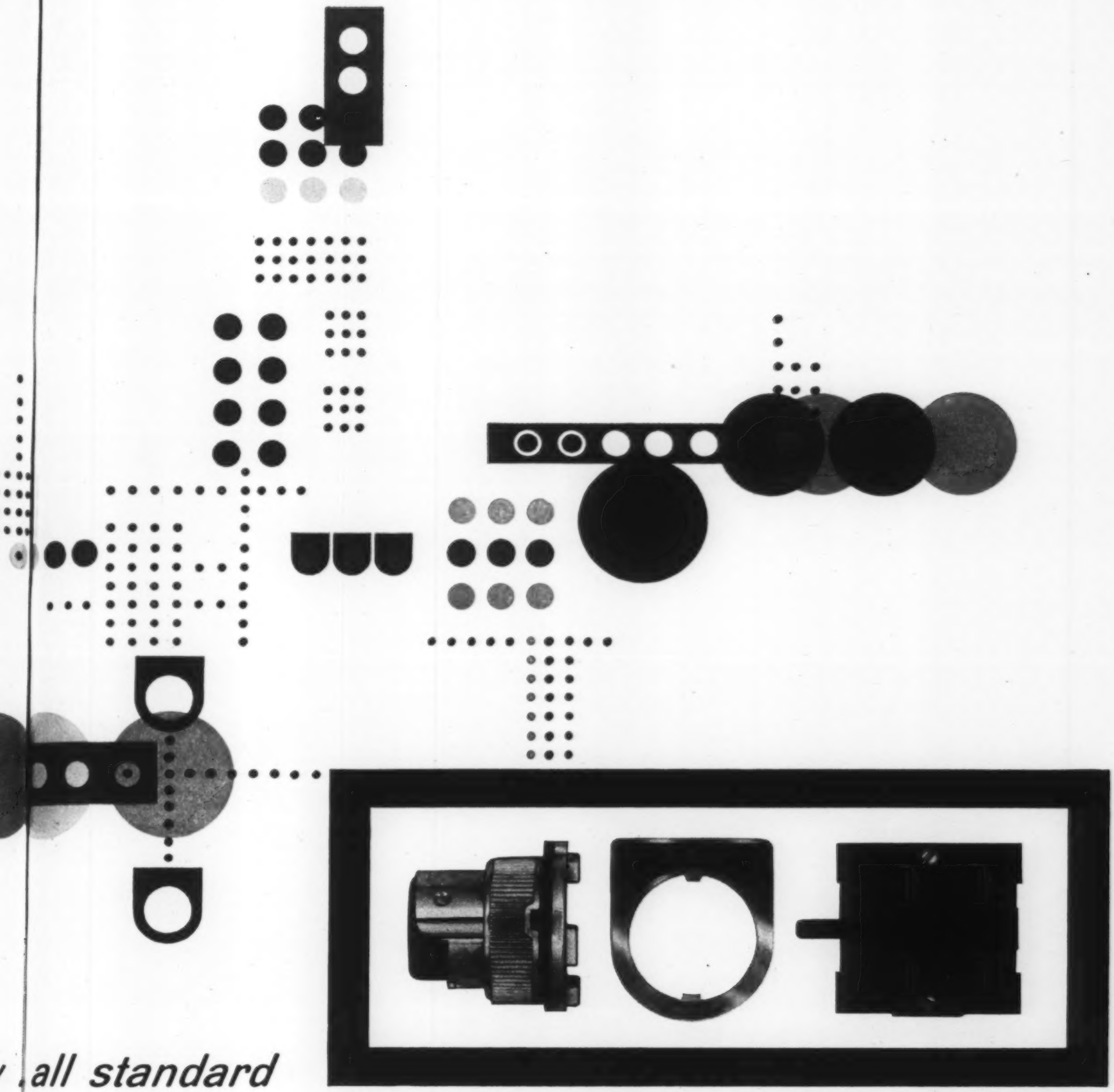
KOPPERS

**MECHANICAL SHAFT SEALS**

*Circle 527 on page 19*



*Pushbutton control arrangements almost to infinity .a*



*all standard*

How'd you like a stock of 1,500,000 pushbutton controls on hand at all times for original equipment needs or for production purposes?

Sound prohibitive space-wise, or too expensive? Not at all. Just 38 Westinghouse components (shown above) do it because all parts are standardized and interchangeable. And always available from stock.

If you need controls for any application, write for the free 72-page *Pushbutton Guide,* B-6749. For control where moisture is a problem, write for free Booklet, B-7022, about Oil-Tite* controls. Write to Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. Or call your Westinghouse Distributor.

*T. M. J-30248

**YOU CAN BE SURE...IF IT'S**

**Westinghouse**

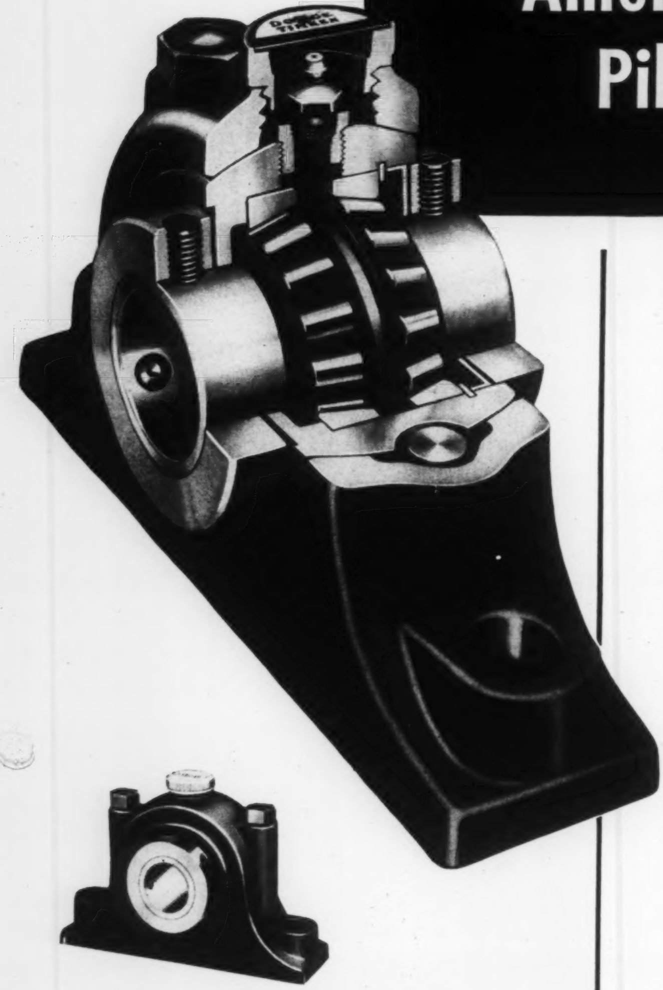
*Circle 528 on page 19*

XUM

# AVAILABLE IN FIVE TYPES FOR ALL KINDS OF SERVICE

# DODGE-TIMKEN

## America's Quality Pillow Block



DODGE-TIMKEN Bearings are adjusted, lubricated and sealed at the factory. Labrynth seals effectively retain the lubricant and prevent the entrance of dust and dirt. The inbuilt precision of Dodge-Timken Bearings is protected both on and off the shaft. They are delivered fully assembled, ready to mount.

Where service conditions are toughest Dodge-Timken Bearings prove their quality decisively. For superior performance, dependability and long life they have won their reputation throughout industry as America's quality pillow blocks.

To meet varying service requirements Dodge-Timken Pillow Blocks are available in five types—the type E.. Double Interlock (illustrated)..Type C.. Special Duty ... and All-Steel. Available in a range of shaft sizes from 1-3/16" to 10".

Call your Transmissioneer; or write for Bulletin A638 giving load ratings, dimensions and other data on Dodge-Timken Roller Bearings.

**DODGE MANUFACTURING CORPORATION**
**3300 Union Street, Mishawaka, Indiana**

- **COMPLETELY ASSEMBLED**
- **FACTORY ADJUSTED**
- **PRE-LUBRICATED**

**Call the Transmissioneer, your local Dodge Distributor. Factory-trained by Dodge, he can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified telephone directory, or write us.**

**DODGE**
*of Mishawaka, Ind.*

*Circle 529 on page 19*

*only*

## CLEARPRINT Tracing Paper

***does so many things so well!***

For the perfect working surface, for ghost-free prints, for proven stability - Clearprint Technical Paper has no equal. Since its introduction in 1932, other paper makers have strived to duplicate Clearprint's quality. None has succeeded. Your drawings deserve this superior paper. Insist on genuine Clearprint, *watermarked* for your protection.

**THERE'S A CLEARPRINT PAPER FOR EVERY JOB**

Tracing Paper • "Papercloth"
Clearprint Charts
Federal Aid Sheets
"Fade-Out" Grid Paper

**IN SHEETS, PADS and ROLLS**

**YOU BE THE JUDGE...**

**Make this simple**

**CLEARPRINT TEST**

**1. INVITES PENCIL AND PEN —**

**Try Clearprint's perfect working surface with a 2H pencil, then with a ruling pen. Lines are sharp and clean — no feathery edges.**

**2. NO GHOSTING —**

**Erase some of the lines. Redraw and erase several of them repeatedly. Crease the paper, too. Then hold it to the light, or make a reproduction. Seeing is believing!**

**3. NEVER CHANGES —**

**Sheets in use since 1932 prove Clearprint does not tear or become "dog-eared" in the files. Its strength, transparency and printing qualities remain unchanged after extended exposure to age, atmosphere, heat and light.**

**Make this test, too, on the paper you are now using. The difference will convince you.**

3

**CLEARPRINT**

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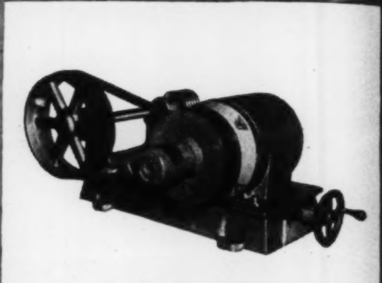
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# ● WIDENING THE HORIZONS OF

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Reliance can provide *you* with valuable engineering assistance which can help secure the advantages of automation.

Our Tools of Automation consist of electric motors, variable-speed drives and controls.

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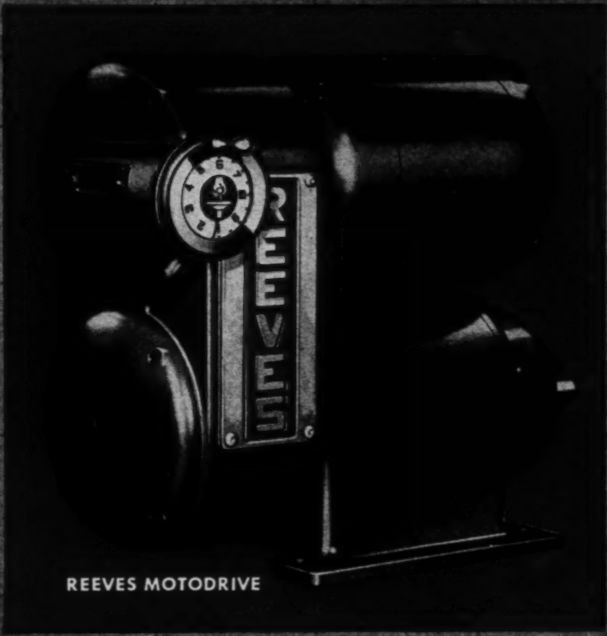

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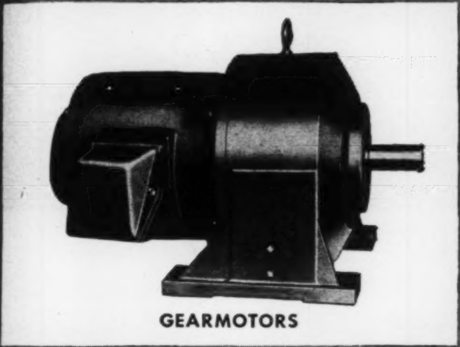
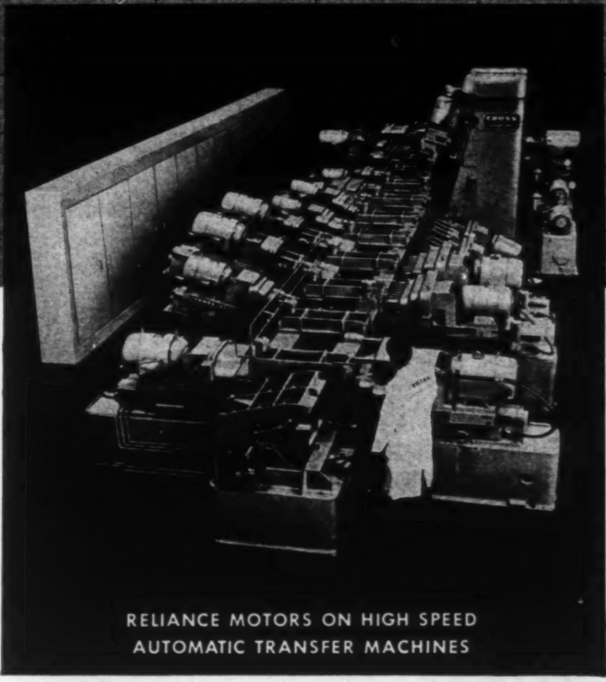


GEARMOTORS



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# AUTOMATION

Application of these tools ranges from a single motor to multi-motor drives for highly complex production lines, where materials are processed into finished products in one continuous operation.

The world's largest manufacturer devoted exclusively to the production of quality motors and drives is ready to help you widen the horizons of automation in your plant.

Bulletin No. A-1555-B gives further details.

A-1519

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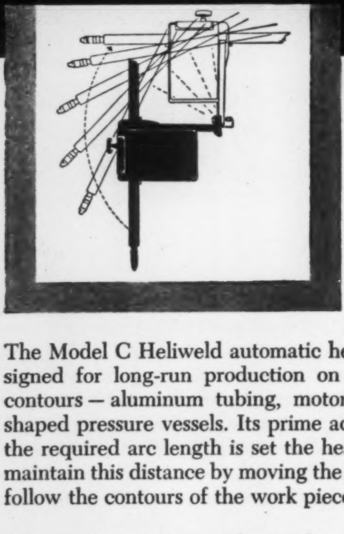
HELIWELD AUTOMATIC HEAD CONTROL PANEL
HELIWELD AUTOMATIC HEAD



New Airco Model C Heliweld automatic head operates at all angles from horizontal to vertical.

# Airco introduces New Automatic Heliweld Head for long-run production welding

The Model C Heliweld automatic head is specifically designed for long-run production on regular or irregular contours — aluminum tubing, motor stators, irregularly-shaped pressure vessels. Its prime advantage is that once the required arc length is set the head will automatically maintain this distance by moving the holder up or down to follow the contours of the work piece. Other benefits are:

- **Versatility** — unit provides good arc voltage control using either argon or helium shielding gases or mixture of both.
- **Adaptability** —the head can be operated at all angles from the horizontal to the vertical (normal) position. The maximum raise-lower distance of the electrode holder is a full 16″.
- **Flexibility** — the assembly can be used for AC or DC welding, with or without filler wire. Electrode diameters range from .020 to 1/8″.

The use of the new automatic head will be required where welds of consistent dimensions and quality are important and where good weld appearance is necessary or where welding specifications are very high for the electrical, aircraft, and refrigeration industries. Complete information covering the wide range of applications and detailed specification data is available. Write Airco at the first opportunity.

*AT THE FRONTIERS OF welding PROGRESS YOU'LL FIND . . .*

AIRCO

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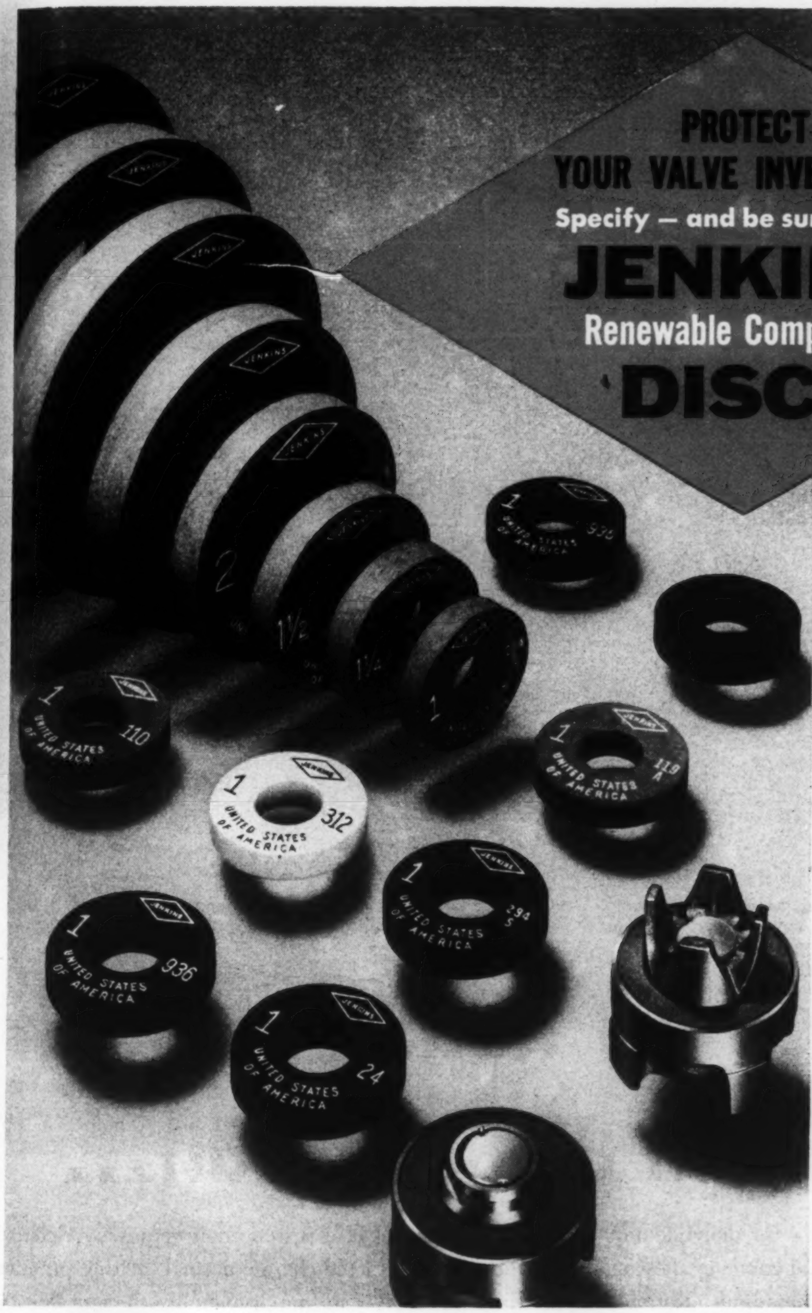
Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetates, alcohols, and other synthetic resins.

*Circle 532 on page 19*

**LOOK FOR THE JENKINS DIAMOND**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1¼
1
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1 UNITED STATES OF AMERICA 312
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1 UNITED STATES OF AMERICA 119 A
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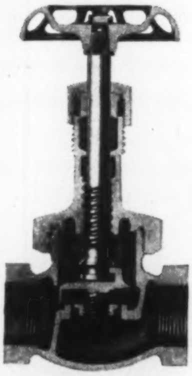
Describes all Jenkins Discs, and their applications for steam, hot and cold water, air, gas, oil, gasoline . . . including the new TEFLON® DISC for lasting, dependable control of oxygen and other gases, solvents, acids, alkalies, and other chemicals,—and for liquid food and similar services.

Ask your Jenkins Valve Distributor for Disc Folder Form 203, or write: Jenkins Bros., 100 Park Ave., New York 17.



**. . . for highest efficiency, use the time-proved combination . . . JENKINS DISCS in**

# JENKINS VALVES

GUIDE TO SELECTION OF JENKINS DISCS

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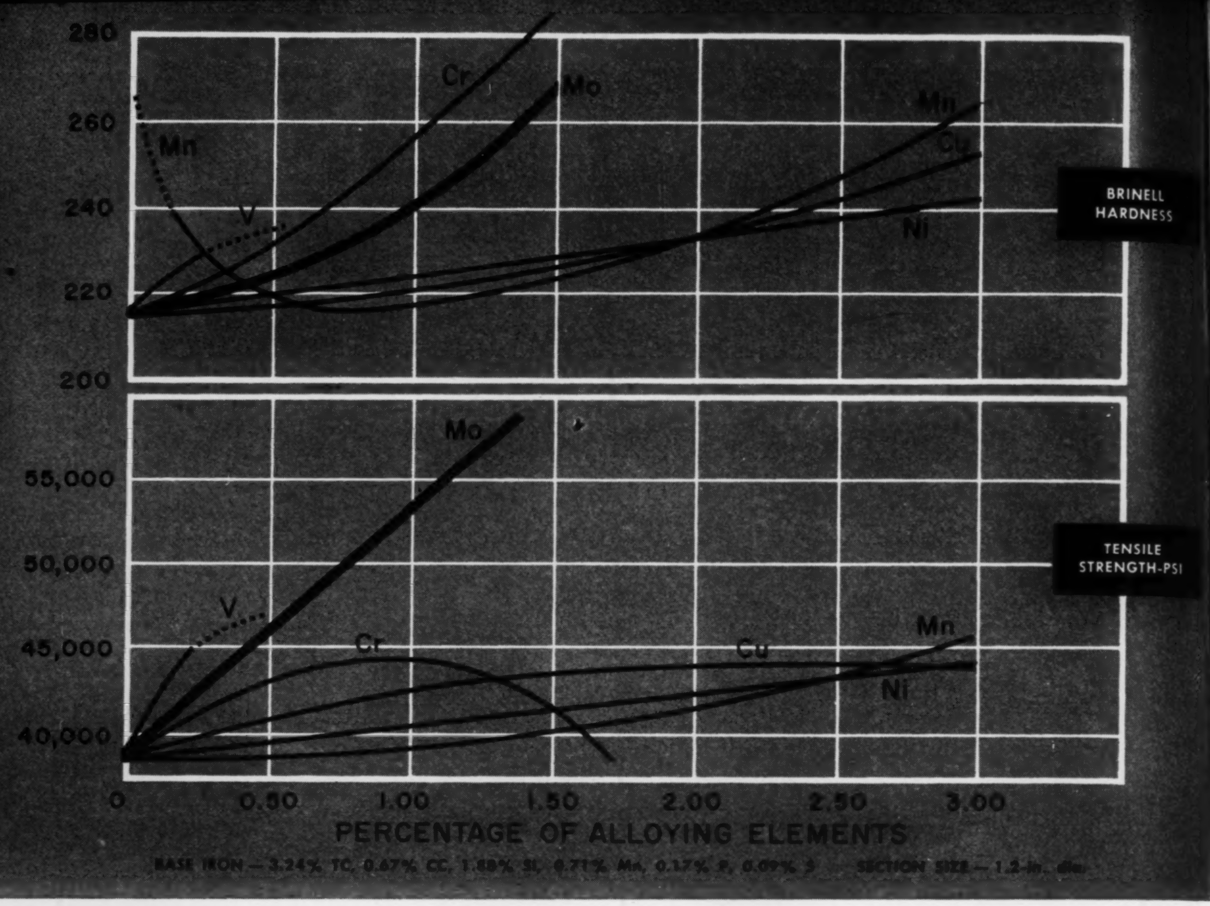
**Order from Your Local Jenkins Distributor**

*Circle 533 on page 19*

XUM



Note how additions of moly, up to 1.5%, produce proportional improvements in strength. And, with moly, hardness increases much more slowly. It means higher strengths can be used with less danger of impaired machinability.

# each ½% Moly adds 7000 psi to strength of cast iron...

A little moly adds a lot of strength — for molybdenum increases strength more than any other common alloying element, with the exception of small vanadium additions. A rule of thumb is that fifty points of moly raise tensile strength 7000 psi. And without sacrificing toughness. Actually, moly improves toughness at least as much as strength.

What's more, versatile moly aids in obtaining uniform response to heat treatment . . . and in producing machinable, growth-resistant castings. Moly is easy to use, too.

With most grades of cast iron, moly requires no change in the character of the charge, normal melting practice, or the base metal. And foundrymen like the fact that the small additions necessary may be made at the spout or in the ladle.

Write now for "Why Moly Iron". It's the full story of how and why moly adds strength faster than hardness, how it increases fatigue and torsional strength—in short why moly makes better cast iron. Climax Molybdenum Co., Dept. 11, 500 Fifth Avenue, New York 36, N. Y.

**CLIMAX MOLYBDENUM**

*Circle 534 on page 19*

CLIMAX MOLYBDENUM

Use the Moly key for better castings

- Toughness
- Strength
- Uniformity
- Wear resistance
- Machinability
- Economy
- Response to heat treatment

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The Enjay Company proudly invites you to inspect the new polymer wing of the Enjay Laboratories, located in Linden, N. J. Continuing the tradition of pioneering in petrochemicals, Enjay has built this new laboratory addition for application research and development exclusively in the polymer division.

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High speed electronic data processing equipment helps the Enjay scientists solve your compounding problems in record time. In developing new products, or improving old ones, call on Enjay for top-notch assistance. Contact your Enjay representative for further information.

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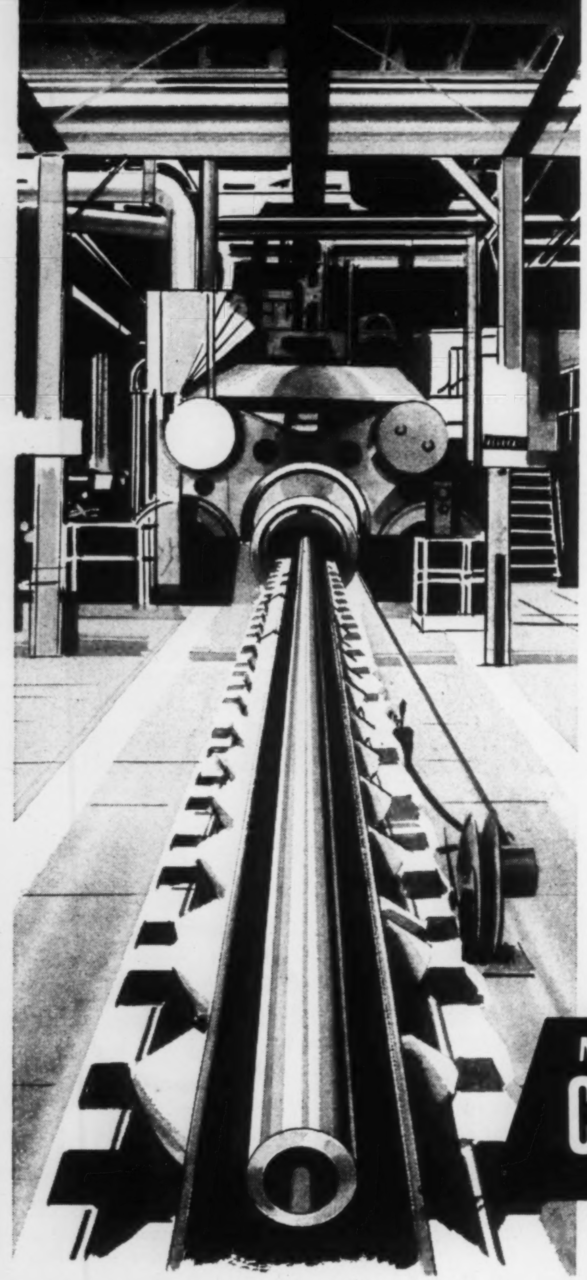
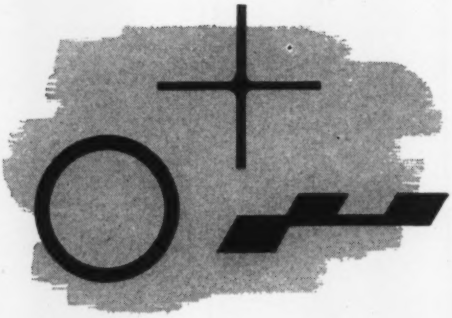
# Shaping a new future for Industry





## CURTISS-WRIGHT extrudes steels in shapes, lengths and sizes never before possible

Curtiss-Wright's Metals Processing Division is pushing steels into new uses for all industries. Shapes and sizes never before possible are being extruded in constantly increasing tonnages from alloy steels, stainless, titanium and other metals.

Starting with billets weighing up to 9000 pounds, the world's largest horizontal steel extrusion press moves the metal into shapes of virtually any profile that can be circumscribed by a 20-inch circle. Or, in a matter of seconds, the raw material may become heavy wall tubing up to 22 inches in diameter.

The 12,000 ton extrusion press and the complete facilities of Curtiss-Wright's Metals Processing Division are ready to go to work for you . . . to advance the design and production of metal products beyond the limitations of conventional equipment. Qualified engineering consultation available at all branch offices.

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*Circle 536 on page 19*

# NEW THREAD CUTTING FASTENER

- LOW COST
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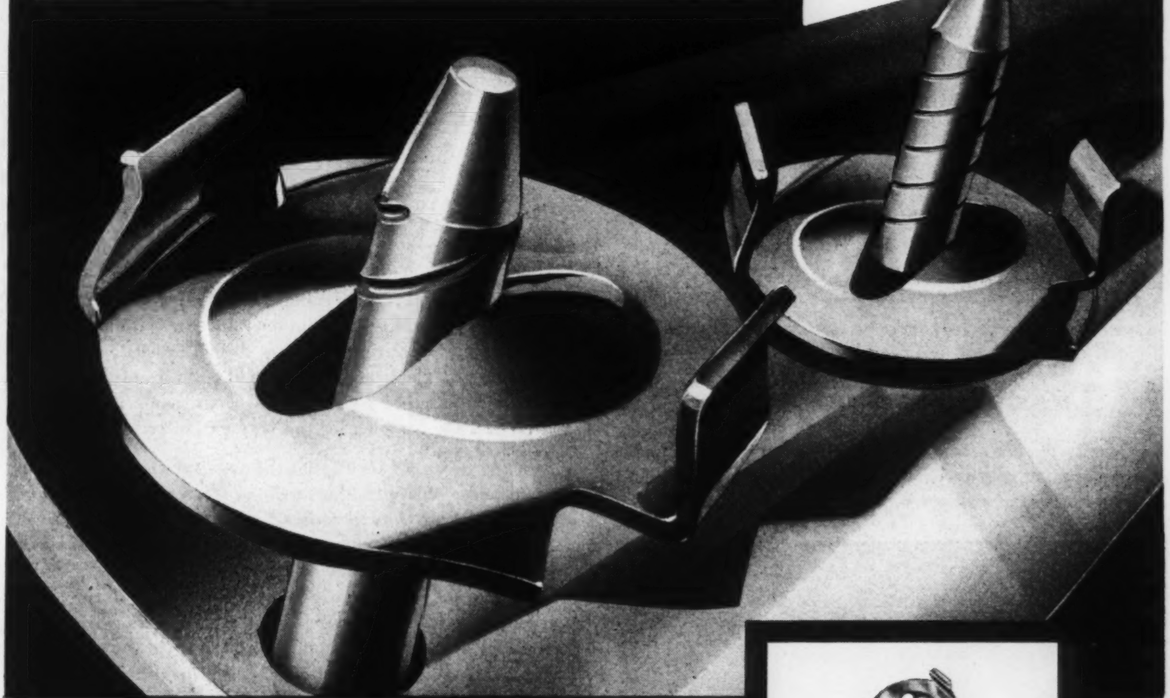
- SELF-LOCKING
- VIBRATION-PROOF
- SPRING TAKE-UP

*Pulls up tight without backup on flat or contoured surfaces*



**T.C.F. for 1/8" stud shown actual size. Also available for 3/16" stud.**

**T.C.F. for 1/8" stud with plastic sealer.**

Specially designed to hold die-cast or cold-forged name plates, emblems and trim against sheet metal surfaces, DOT's new T. C. F. cuts clean, deep threads on unthreaded studs, even those that are chrome plated. Immediately available to fit 1/8" and 3/16" studs.

When used with its pre-assembled plastic sealer, the new T. C. F. makes a watertight seal. The sealer *precedes* the fastener onto the stud so that it is not damaged by the thread-cutting process.

Available *in quantity* with or without sealer from Monadnock Mills subsidiary and Carr Fastener Division.

*United-Carr's design staff is ready to apply the same engineering creativity that produced the T. C. F. and thousands of other special-purpose fastening devices to the solution of your special fastening problems. Field representatives are located in most principal cities.*

**MONADNOCK MILLS**
SUBSIDIARY
San Leandro, California

**DOT T.C.F.**
THREAD CUTTING FASTENER

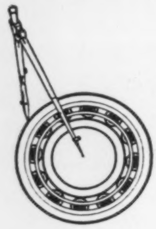
**CARR FASTENER CO.**
DIVISION
Cambridge, Massachusetts

UNITED-CARR FASTENER CORPORATION

Circle 537 on page 19

**ONE OF A SERIES OF INFORMATIVE MESSAGES FROM HYATT . . .**

# The Inside Secrets of Smoother Performance

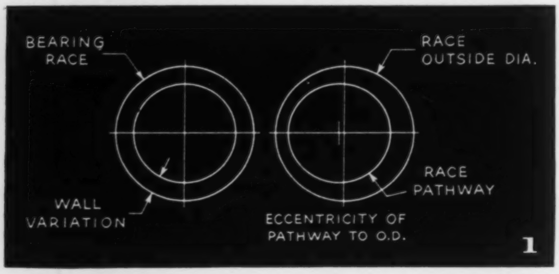


## How HYATT quality controls assure race concentricity, roller diameter uniformity and other internal essentials of smoother, longer-lived cylindrical roller bearings . . .

The running accuracy and smoothness of a roller bearing is governed primarily by its internal dimensions and clearances. The most important of these are:

### 1. CONCENTRICITY OF RACE DIAMETERS

*Eccentricity of race diameters* is usually interpreted in terms of *wall variation*, Figure 1, on the individual components and in terms of *radial run-out* on the assembled bearing. The assembled bearing is usually mounted on an arbor, Figure 2, having a slight taper (.0001″ to .0002″ on the diameter per inch of length) and the radial run-out indicated as shown. The radial run-out is the difference between the minimum and maximum readings obtained when rotating the outer race one revolution with the arbor stationary for outer race radial run-out, or rotating the arbor one revolution with the outer race stationary for inner race radial run-out.



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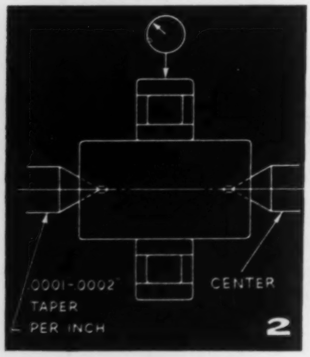


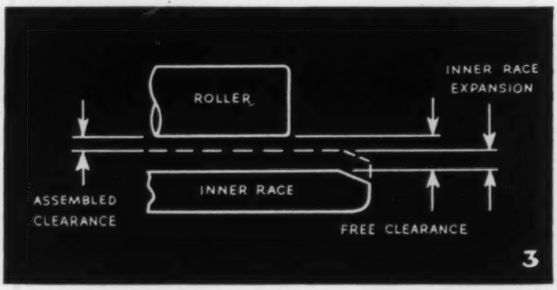
2

### 2. UNIFORMITY OF ROLLER DIAMETERS

Another factor governing running smoothness is *roller diameter uniformity*. This is usually obtained by segregating the rollers into diameter variation classes of .00005″, .0001″, or .00015″, depending on the bearing size and the nature of the application, and assembling only rollers of the same group into a given bearing. Gauging for this segregation necessarily rejects excessive taper.

Uniformity of roller diameters is important for another purpose. It provides the user with a bearing in which the internal diametral clearance is controlled within the closest possible limits. The rollers are matched with races which are segregated for pathway size in a fashion similar to the rollers, usually to twice the diameter limits of the rollers. The internal clearance can thus be manipulated at will by combining various diameter classes of races and rollers; but once a particular range is selected, it will remain constant within the combined limits of the roller and race pathway diameter limits. Here, again, a tapered condition of the race pathway is automatically rejected.

Obviously, the internal clearances of commercial bearings must be standardized for the practical reasons of cost and availability, but the clearance values have been so selected that under the specified fits the *running* clearance is at the most desirable minimum, depending on bearing type and size. Figure 3 (magnified).



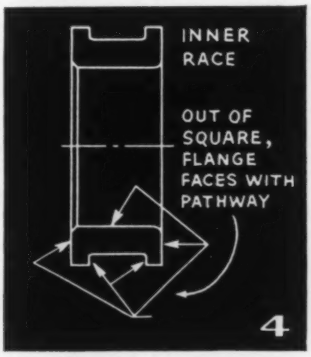
3

*Checking wall variation, flange run-out and race end squareness on combination gauge.*

## 3. SQUARENESS OF ROLLER ENDS AND FLANGE FACES

One other tolerance that contributes to the running efficiency of HYATT Hy-Load Series Bearings of the flanged race type is the *squareness of roller ends with roller diameters* and the *squareness of flange faces with the race pathways.*

Flanged race bearings are commonly used for locating shafts laterally and for running conditions of light and intermittent thrust load. For best operating results, the ends of the rollers must be flat and square with the diameter within a matter of tenths. The lateral clearance between the roller and the race shoulders must also be held to a minimum. This means close tolerances on roller length and race pathway width, and the flange face, Figure 4, must be square with the roller pathway. When all these conditions are satisfied, there will be no tendency for the rollers to skew and raise the operating temperature of the bearing, nor will there be any unusual force on the separator or cage with a tendency toward wracking and noisy operation.



4

The *side run-out* of the individual races or the *out-of-square* of the ends with the fitting diameters is also important, especially in applications where a number of parts are held together endwise and where the pressure might be sufficient to tilt the race, creating a condition of excessive taper on the roller pathway with consequent roller skewing and the development of excessive heat and noise.

All these internal dimensions and clearances are so carefully controlled that HYATT Hy-Roll Bearings have built an unsurpassed reputation among design engineers for exceptionally long, smooth and trouble-free performance.

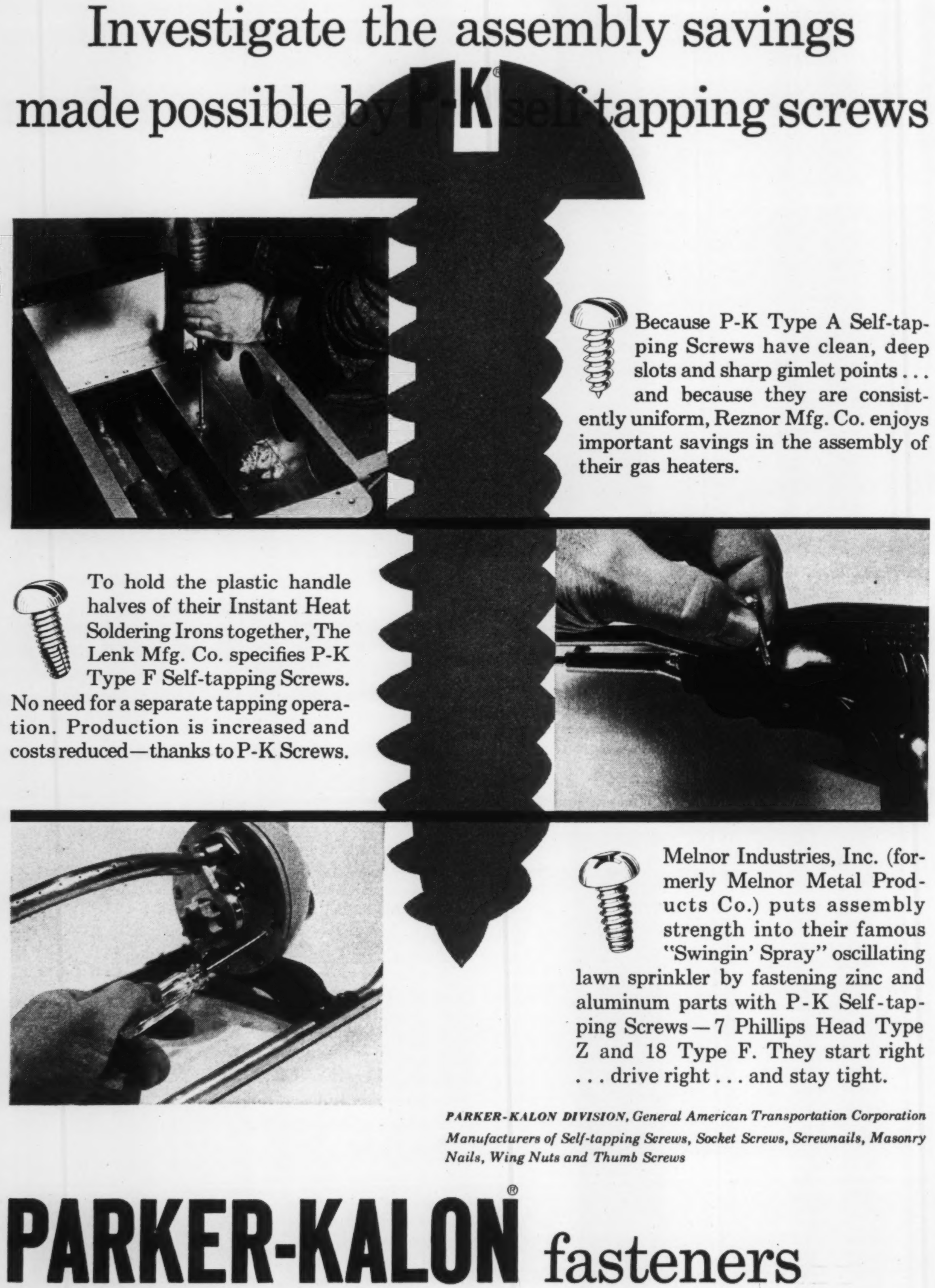
**YOU WILL FIND MORE DETAILS**

**in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your design requirements. Remember, HYATT is America's first and foremost maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors Corporation, Harrison, New Jersey.**

GM
GENERAL MOTORS

**HYATT *HY-ROLL BEARINGS***
**FOR MODERN INDUSTRY**

*Circle 538 on page 19*



# Investigate the assembly savings made possible by P-K® self-tapping screws

Because P-K Type A Self-tapping Screws have clean, deep slots and sharp gimlet points . . . and because they are consistently uniform, Reznor Mfg. Co. enjoys important savings in the assembly of their gas heaters.

To hold the plastic handle halves of their Instant Heat Soldering Irons together, The Lenk Mfg. Co. specifies P-K Type F Self-tapping Screws. No need for a separate tapping operation. Production is increased and costs reduced—thanks to P-K Screws.

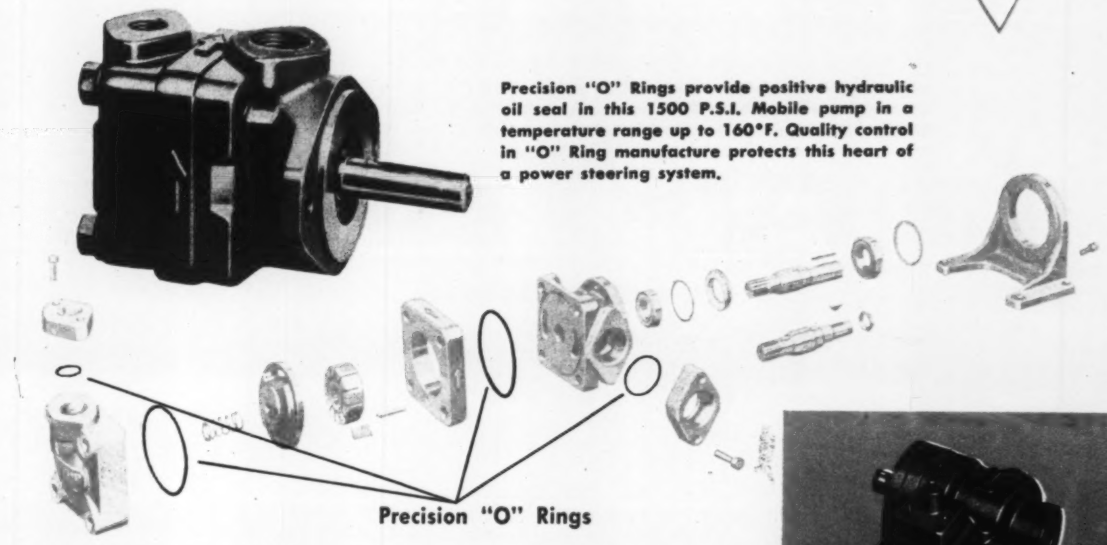
Melnor Industries, Inc. (formerly Melnor Metal Products Co.) puts assembly strength into their famous "Swingin' Spray" oscillating lawn sprinkler by fastening zinc and aluminum parts with P-K Self-tapping Screws — 7 Phillips Head Type Z and 18 Type F. They start right . . . drive right . . . and stay tight.

*PARKER-KALON DIVISION, General American Transportation Corporation*
*Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws*

**PARKER-KALON®** fasteners

*Sold Everywhere Through Leading Industrial Distributors*
*Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois—Los Angeles, California*

# Precision "O" Rings protect the Heart of Hydraulic Power Steering Systems.



**Precision "O" Rings provide positive hydraulic oil seal in this 1500 P.S.I. Mobile pump in a temperature range up to 160°F. Quality control in "O" Ring manufacture protects this heart of a power steering system.**

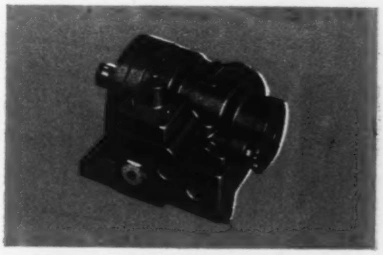
**Precision "O" Rings**

There can be no compromise on quality and reliability in hydraulic power steering pumps. VICKERS Incorporated, of Detroit, Mich., the world's largest manufacturer of fine hydraulic pumps, use Precision "O" Rings to assure dependable, long life performance under exacting conditions.

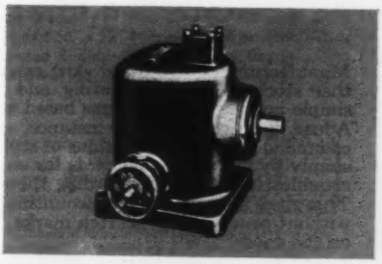
Precision "O" Rings are used in the majority of VICKERS mobile and industrial hydraulic pumps. For VICKERS Incorporated and hundreds of other manufacturers, the use of Precision "O" Rings means economical, efficient, leak-proof operation.

Precision compression molded "O" Rings are rigidly inspected – quality-controlled – meet all military and commercial specifications – the finest made! Precision can furnish the size and compound that fits your product requirements.

Place your sealing problem in the hands of an expert – the Precision engineer. He can assist you in product design. Rely on Precision, the world's largest exclusive producer of "O" Rings.



**In VICKERS constant delivery vane type pumps, used on Industrial machinery, Precision "O" Rings are used in pump, unloading and pressure relief valve sections to provide effective seals against hydraulic oil leakage.**



**In VICKERS variable delivery piston type pumps, used on Industrial machinery, Precision "O" Rings give exacting service in sealing against hydraulic oil pressure up to 3000 P.S.I.**

**Write for your free copies of Precision catalogs on "O" Rings and Dyna-seals**

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*Circle 540 on page 19*

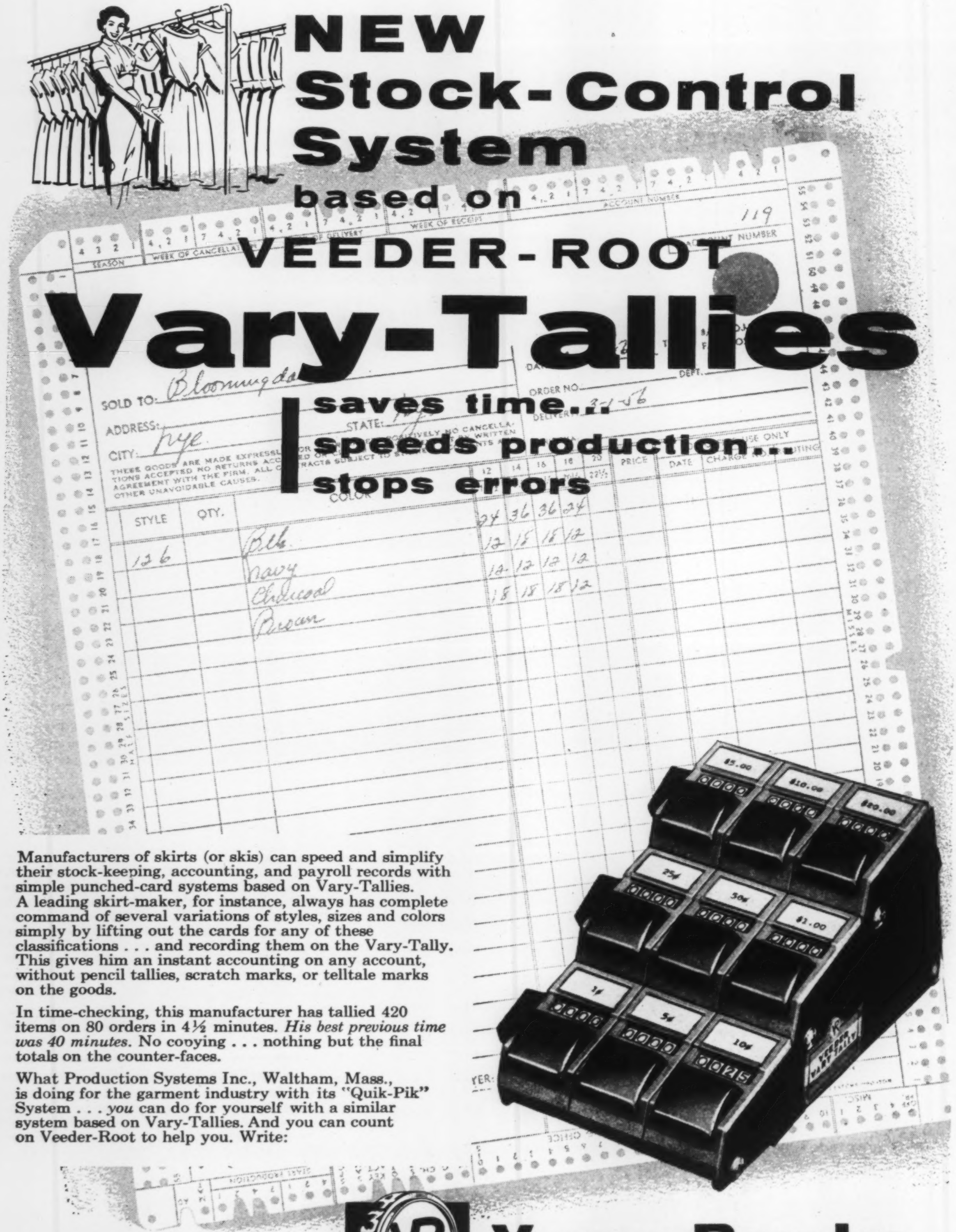
# NEW Stock-Control System

based on

## VEEDER-ROOT

# Vary-Tallies

**saves time...**
**speeds production...**
**stops errors**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WEEK OF CANCELLATION
WEEK OF DELIVERY
WEEK OF RECEIPT
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119
SOLD TO: Bloomingdale
ADDRESS:
CITY: Rye
STATE: NY
ORDER NO. 3-1-56
DEPT.
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COLOR
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VEEDER VARY-TALLY

Manufacturers of skirts (or skis) can speed and simplify their stock-keeping, accounting, and payroll records with simple punched-card systems based on Vary-Tallies. A leading skirt-maker, for instance, always has complete command of several variations of styles, sizes and colors simply by lifting out the cards for any of these classifications . . . and recording them on the Vary-Tally. This gives him an instant accounting on any account, without pencil tallies, scratch marks, or telltale marks on the goods.

In time-checking, this manufacturer has tallied 420 items on 80 orders in 4½ minutes. *His best previous time was 40 minutes.* No copying . . . nothing but the final totals on the counter-faces.

What Production Systems Inc., Waltham, Mass., is doing for the garment industry with its "Quik-Pik" System . . . *you* can do for yourself with a similar system based on Vary-Tallies. And you can count on Veeder-Root to help you. Write:

**VEEDER-ROOT INC.**

*"The Name that Counts"*

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New York • Los Angeles • San Francisco • Montreal
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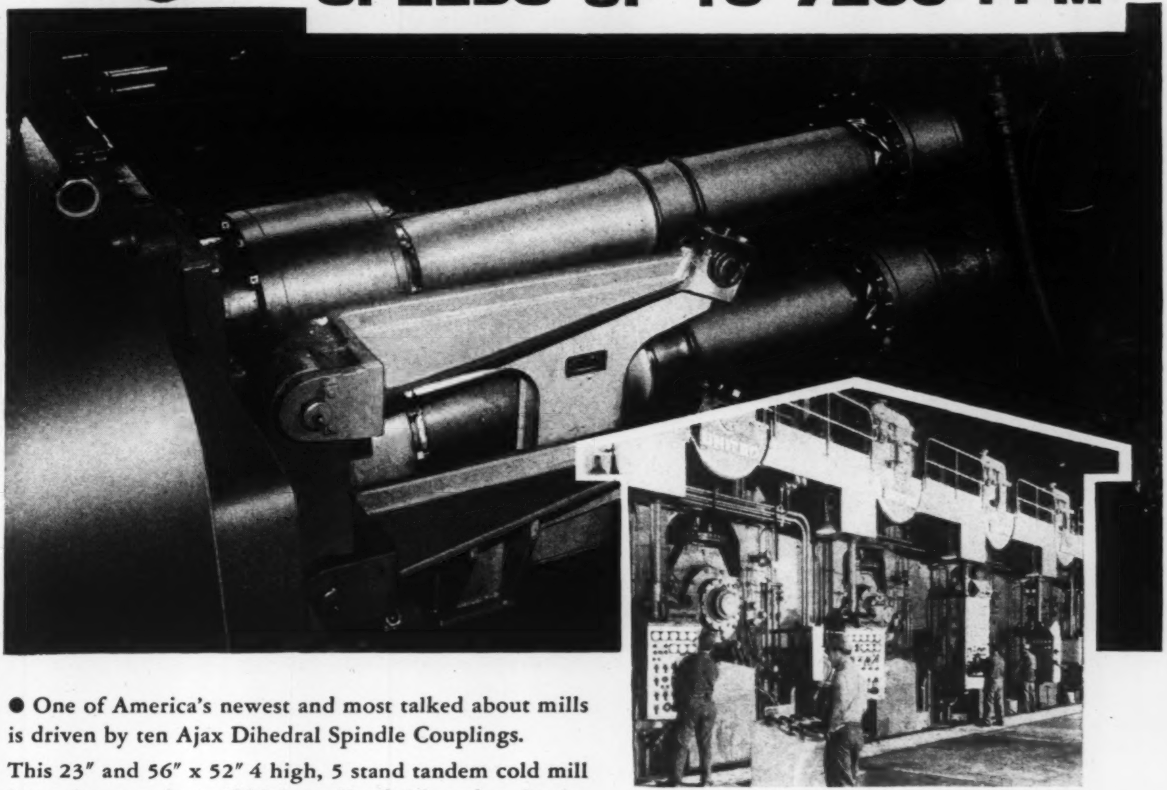
Circle 541 on page 19

**AJAX**®

# DIHEDRAL SPINDLE DRIVE COUPLINGS HANDLE SPEEDS UP TO 7200 FPM



Close-up shows two of five pairs of Ajax Dihedral Spindle Couplings driving 23" and 56" x 52" 4 high 5 stand tandem cold mill built by United Engineering & Foundry Co. in operation at Weirton Steel Co., a Division of National Steel Corporation.

- One of America's newest and most talked about mills is driven by ten Ajax Dihedral Spindle Couplings.

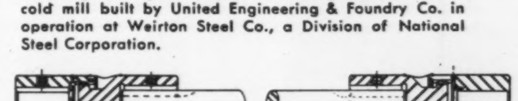
This 23" and 56" x 52" 4 high, 5 stand tandem cold mill is turning out sheet of high quality finish and maintaining close gauge tolerance at speeds up to 7200 fpm.

Uniform angular velocity made possible by Ajax Dihedral Spindle Couplings is an important factor in the performance of this high speed mill built by United Engineering & Foundry Co. for Weirton Steel Co., a Division of National Steel Corporation.

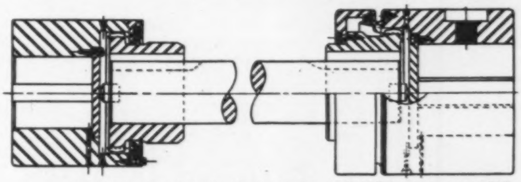
Each of these couplings delivers 2500 hp between drive stand and rolls.

The proven performance of Ajax Dihedral Spindle Couplings is writing new standards into the specifications of mill builders and new figures into the production and maintenance cost records of mill users.

The long experience of Ajax engineers is available to help you in all phases of design, application and operation. Call in the Ajax representative or write us direct.



Another typical style of Ajax Dihedral Spindle Shaft Couplings in several sizes for roll mill drives. Sketch shows 9" diameter by 5' 6" overall length Ajax Dihedral Spindle Shaft Coupling. Arranged for booted lubricant retainer seal.



Showing Ajax Dihedral Spindle Shaft Coupling 6' 4½" overall with 15¾" diameter coupling on roll end and 13¾" diameter coupling on drive end. Rated torque capacity of this Coupling is approximately 110,000 ft. lbs.

## AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD, N. Y.

*Circle 542 on page 19*

## When you plan for COST REDUCTION — use this time-proved FORMULA

**Selection from the**

**BOSTON *Gear* CATALOG**

**All the parts you need from the complete line of 7124 STANDARDIZED PRODUCTS**

**+**

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COMPLETE CATALOG 56
POWER TRANSMISSION PRODUCTS
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**MORE SPROCKETS** — New, standard stock BORED-TO-SIZE Sprockets — complete with keyway and set screw, ready to install — your choice of 76 tooth sizes, 321 stock bores. Also lists full line of SHOLD-A-GRIP taper-bored Sprockets and Bushings.

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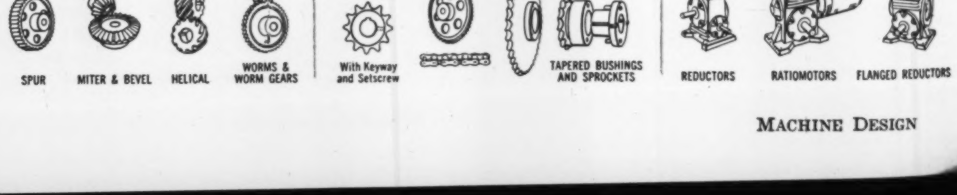
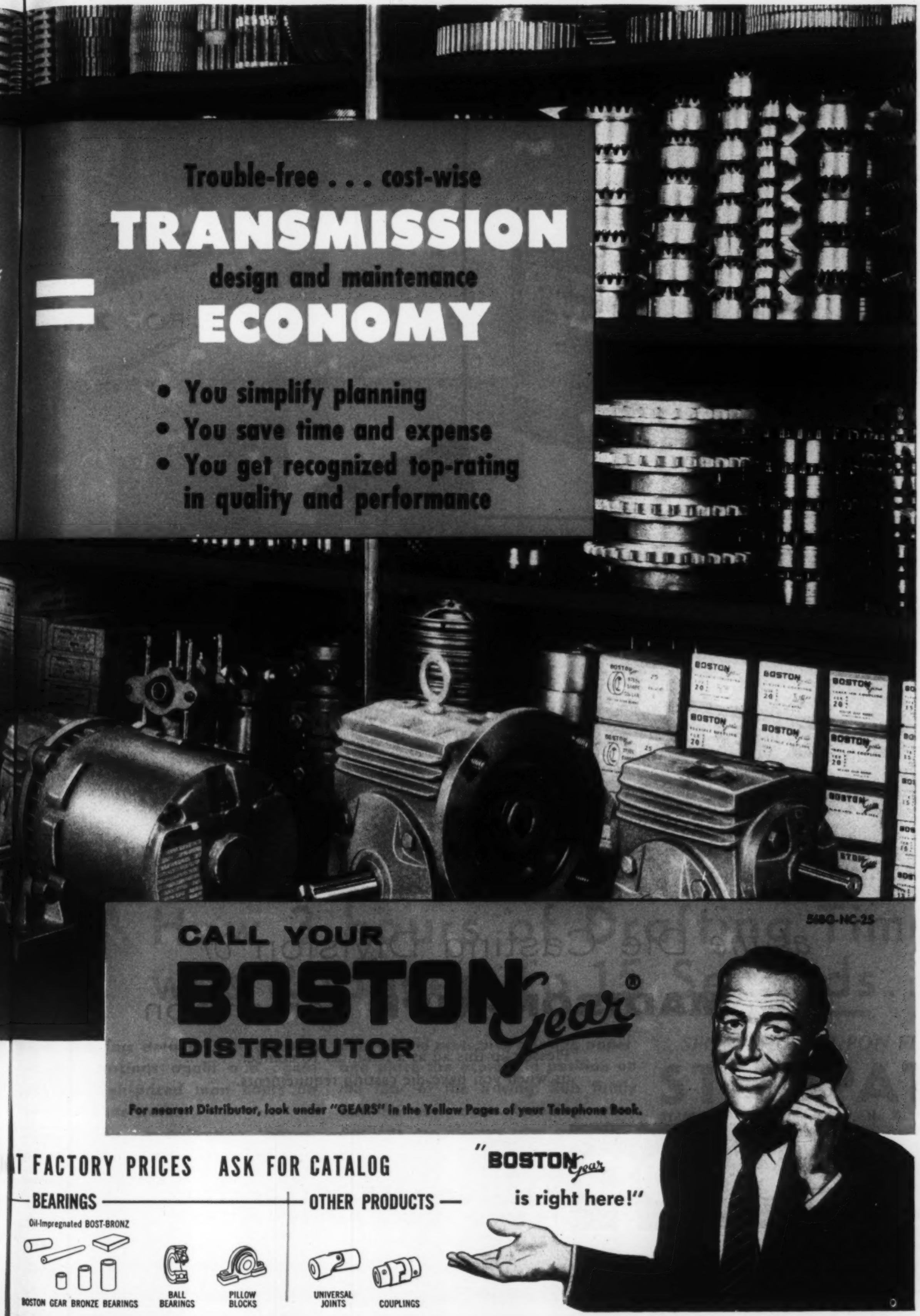
Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

**7124 "OFF-THE-SHELF" TRANSMISSION PRODUCTS FROM YOUR DISTRIBUTOR**


— STANDARD STOCK GEARS —
SPUR
MITER & BEVEL
HELICAL
WORMS & WORM GEARS
— SPROCKETS & CHAIN —
BORED-TO-SIZE SPROCKETS
With Keyway and Setscrew
INTERCHANGEABLE
TAPERED BUSHINGS AND SPROCKETS
— SPEED REDUCERS —
REDUCTORS
RATIOMOTORS
FLANGED REDUCTORS



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design and maintenance

= ECONOMY

- You simplify planning
- You save time and expense
- You get recognized top-rating in quality and performance

56BG-NC-2S

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For nearest Distributor, look under "GEARS" in the Yellow Pages of your Telephone Book.

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"BOSTON Gear is right here!"

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Oil-Impregnated BOST-BRONZ

BOSTON GEAR BRONZE BEARINGS

BALL BEARINGS

PILLOW BLOCKS

— OTHER PRODUCTS —

UNIVERSAL JOINTS

COUPLINGS

MADISON-KIPP CORP.
MADISON, WIS.
DEEP-DOWN SECURITY
Good housekeeping and excellent metal control have given Madison-Kipp a most outstanding record on both ordnance and commercial products in zinc and aluminum for over a quarter of a century.
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ONE LABEL FOR **AL.**

TWO LABELS FOR **ZN.**

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ZINC DIE CASTINGS
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# ***Significant Labels*** *of modern metal founding*

## *at the* Die Casting Division *of* **MADISON-KIPP** Corporation

Please clip this ad as a reminder to contact us when you have die casting requirements.

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**MADISON-KIPP CORPORATION**
210 WAUBESA STREET • MADISON 10, WIS., U.S.A.

- Skilled in Die Casting Mechanics
- Experienced in Lubrication Engineering
- Originators of Really High Speed Air Tools

*Circle 544 on page 19*

# How 3 hours of Drafting Time was Reduced To 15 Seconds...

Any drawing details that reappear on your tracings again and again pile up high-priced man hours on purely routine work.

Title blocks, specification boxes, notes and instructions, standard components and sub-assemblies, symbols, standard cross sections—any details that recur—can now be applied in a matter of seconds.

Desired material printed on acetate sheets with adhesive applied to the face can be supplied to you in quantity at low cost. To apply, simply peel off the protective backing paper and place the acetate in position on the rear of the tracing. Rub firmly and the job is done. Resulting reproductions are always crisp and clear. When the recurring parts come up again, don't use expensive drafting time—follow the experience of drafting rooms in every major industry—use inexpensive STANPAT.

***Prove to yourself how STANPAT saves time, effort, money. Send us your drawing details now for quotation without obligation.***

*Circle 545 on page 19*

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# ROSS EXCHANGE

## cools oil while this Giant Hufford Uniwelder joins 20 inch tubing

Designed to handle the biggest job ever performed by the uniweld process, the 200-ton Hufford Uniwelder (shown) welds tubing up to 20 inches in diameter and 2 inches thick.

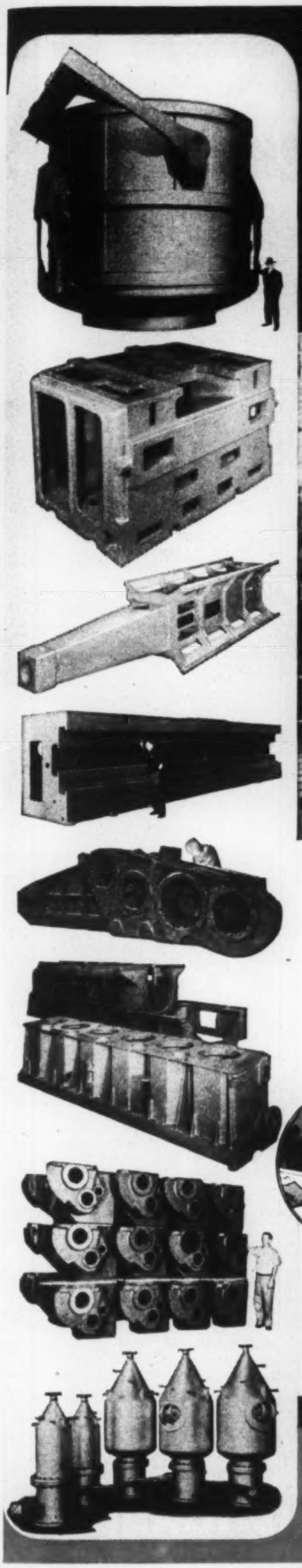
An important component of this welding giant, a Ross Type BCF Exchanger holds hydraulic oil temperature in check. Pump slippage from overheated, thinned oil is thus effectively prevented and rated power insured. Says Hufford Machine Works, Inc., "Ross Exchangers are compact, easy to install and perform satisfactorily . . . We have been using them for several years."

Like Hufford, numerous manufacturers furnish Ross Exchangers with regularity on hydraulic machinery of every description: die casting machines, metal drawing presses, extrusion presses, gear shapers, powder metal presses and fluid drives.

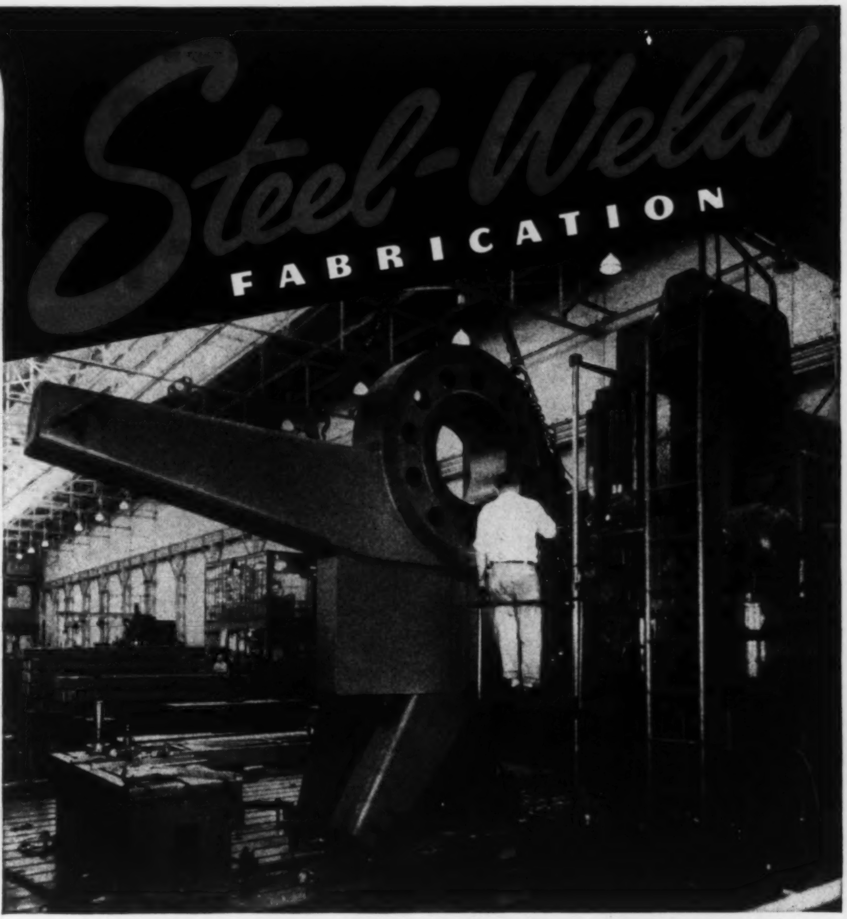
Not only are Ross Exchangers unmatched in thermal efficiency and ruggedness, they're pre-engineered in a wide range of fully standardized sizes to meet most needs. For detailed information, request Bulletin 1.1K5. Ross Heat Exchanger Division of American-Standard, Buffalo 5, New York. In Canada: American-Standard Products (Canada) Limited, Toronto 5, Ont.

ROSS

ROSS HEAT EXCHANGER PRODUCTS



# Steel-Weld FABRICATION



Use WELDED STEEL for Greater Strength with Less Weight!

Being machined above is one of 164 Tripods produced and machined by Mahon for use in the world's largest continuous grinding and polishing machine to be employed in the production of plate glass. Weldments, in almost any type of heavy machinery give you greater strength with less weight—and the additional advantages of greater rigidity and predictability. If you can use weldments in your products, you can turn to Mahon for complete service including design, or redesign, fabrication, machining and assembling. The parts and assemblies illustrated here are typical of thousands of Steel-Weld Fabricated units produced by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. You, too, will find in the Mahon organization a unique and reliable source for welded steel in any form . . . a source with unusual facilities where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or better still, have a Mahon sales engineer call at your convenience.

**THE R. C. MAHON COMPANY • Detroit 34, Michigan**
Sales-Engineering Offices in Detroit, New York and Chicago

*Engineers and Fabricators of Steel in Any Form for Any Purpose*

**MAHON**

*Circle 547 on page 19*

CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
40% SPACE SAVED
T-J
T-J
T-J
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

# Arctic Cargo Carrier Depends On

## T-J *Spacemaker* CYLINDERS

## Saves 40% Space!

## No Tie Rods For Greater Strength

Differential axle loading through T-J Spacemaker Air Cylinders forms a controlled walking beam in this Teracruiser, designed and produced for the Army Ordnance Corps by the Four Wheel Drive Co., Clintonville, Wis.

Weight of cylinders was important factor in choosing T-J Spacemakers, which reduce weight while providing same displacement and extra high safety factor. Fast delivery and space-saving features also favored T-J. Exclusive with T-J are new Super Cushion Flexible Seals for Air (to 200 P.S.I.) . . . and New Self-Aligning Master Cushion for Oil (to 750 P.S.I.). Hard chrome plated bodies and piston rods are standard, at no extra cost. Wide range of styles, capacities . . . 64,000 combinations *off the shelf!* Write for bulletin SM-155-3. The Tomkins-Johnson Co., Jackson, Mich.

**ALL MODELS . . .
OFF SHELF
DELIVERY**

**MEETS WITH
ALL JIC
RECOMMENDATIONS**

**T-J TOMKINS-JOHNSON**
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

Circle 548 on page 19

Circle 549 on page 19→

# Design Punch

## FOR CAR BUILDERS

- Tough, corrosion fighting stainless steel that will resist weather, road abrasion and flying stones, and return to its original brightness when wiped with a damp cloth . . . that's what car buyers want these days.
- Designers with their fingers on the public pulse know this, and that's why next year more stainless steel will be used by the car manufacturers than ever before. A good percentage of this stainless steel will be supplied by Sharon . . . for more than half a century a leading producer of quality automotive steels.

SHARON *Stainless Steel*

**SHARON STEEL CORPORATION** *Sharon, Pennsylvania*

DISTRICT SALES OFFICES: Chicago, Cincinnati, Cleveland, Dayton, Detroit, Grand Rapids, Indianapolis, Los Angeles, Milwaukee, New York, Philadelphia, Rochester, San Francisco, Sharon, Seattle, Montreal, Que., Toronto, Ont.

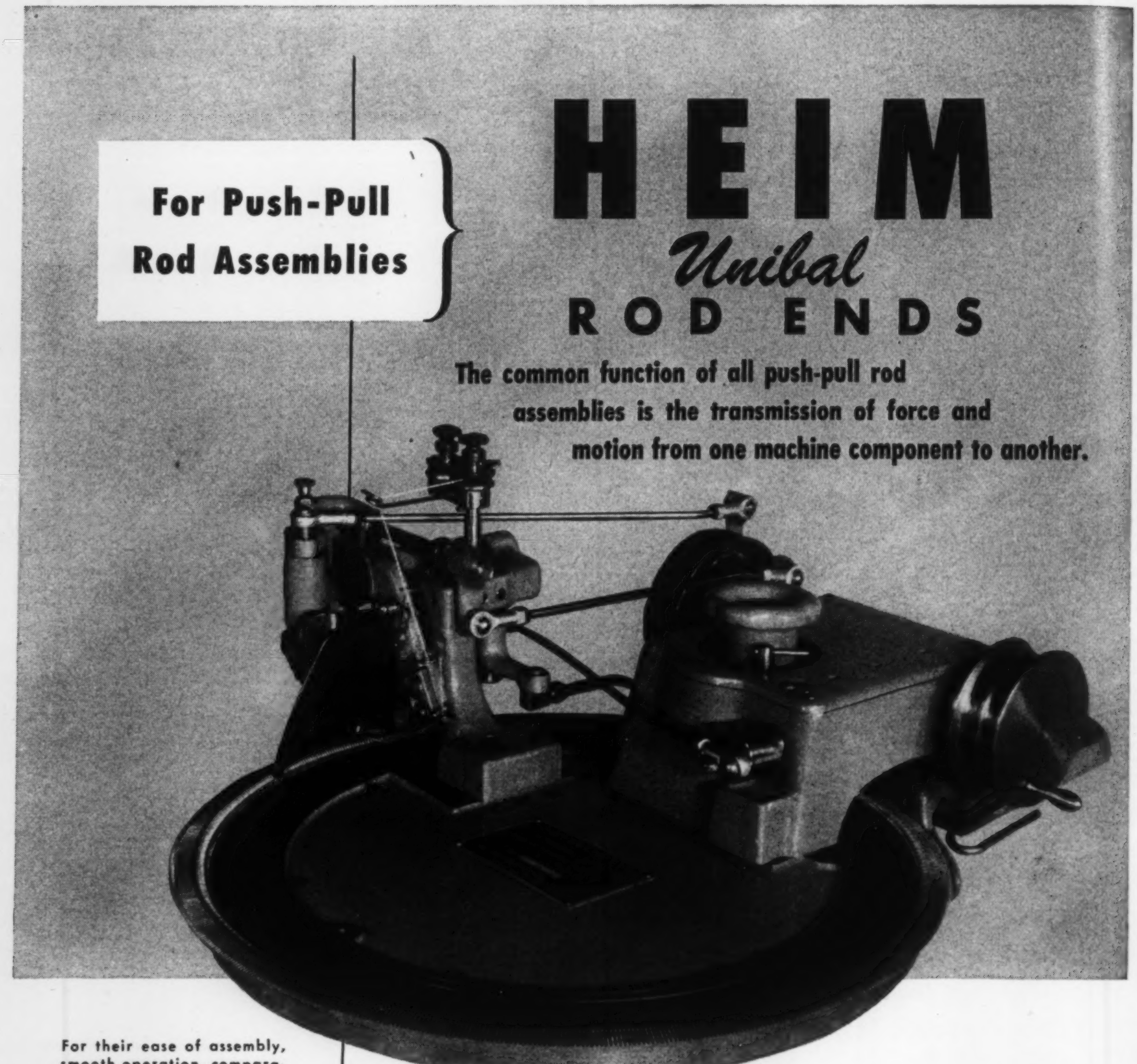
**For Push-Pull Rod Assemblies**

# HEIM

## *Unibal*

## ROD ENDS

**The common function of all push-pull rod assemblies is the transmission of force and motion from one machine component to another.**



For their ease of assembly, smooth operation, comparatively low cost, as well as ability to correct misalignment, choose Heim Unibal Rod Ends.

In the operation of the Sweater-Looper, made in Philadelphia by John W. Hepworth & Co., there is a horizontal drive rod, a vertical drive rod, and a needle drive rod. At both ends of each drive rod are Heim Unibal Rod Ends — for smooth, trouble-free, continuous production.

The Hepworth Sweater-Looper is used for all types of sweater collars, sleeves, and shoulders. Collars can be set on a completely assembled knitted garment in a single continuous operation. Heim Unibal Rod Ends perform so well on the sweater-looper that Hepworth has redesigned their hosiery-looper to include Heim Rod Ends in the linkage assemblies.

*Write for complete catalog, or for any engineering advice.*

**THE HEIM COMPANY**
FAIRFIELD, CONNECTICUT

*Circle 550 on page 19*

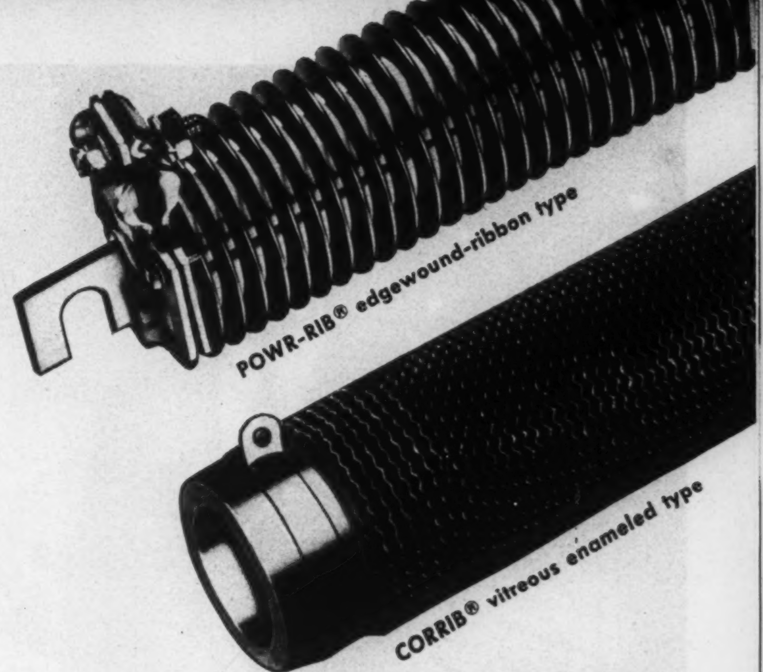
specify

**OHMITE®**

*Power Type*

# RESISTORS

for high current low resistance applications –


POWR-RIB® edgewound-ribbon type
CORRIB® vitreous enameled type

The Ohmite line of specialized CORRIB and POWR-RIB resistors solves your high-current, low-resistance problems. The four basic types of Ohmite units (shown below) handle a wide range of special power resistor needs. They are designed for continuous or intermittent duty and provide dependability for heavy-duty applications. Available in Fixed or Adjustable "DIVIDOHM®" Types.

**IN STOCK**—22 Corrib Resistance Values in 300 Watt Size (Core 8 ½" x 1 ⅛").

**IN STOCK**—26 Powr-Rib Resistance Values in 5 Section Size (17 ⅞" long).

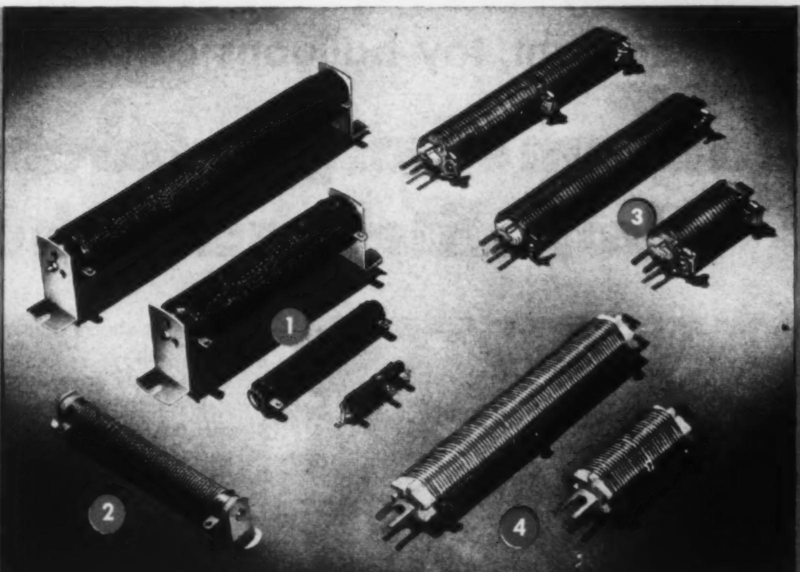
***Write for Bulletin 144***

① **CORRIB®**
**vitreous-enameled corrugated-ribbon type**
Fixed, tapped, and adjustable types in 25 sizes, 90 to 1500 watts. Resistances from .04 to 110 ohms.

② **CORRIB®**
**bare threaded tube type**
For continuous or intermittent operation at higher than normal 375°C temperature rise. In two sizes, from 0.36 to 4.25 ohms.

③ **POWR-RIB®**
**edgewound-ribbon type**
Has ceramic core, sectionalized to resist shock. Four sizes. Values .043 to 1.6 ohms; 24 to 95 amps.

④ **POWR-RIB®**
**round-wire type**
Has sectionalized core similar to ribbon type. Four sizes. Values from .69 to 25 ohms; 5.1 to 18.4 amps.

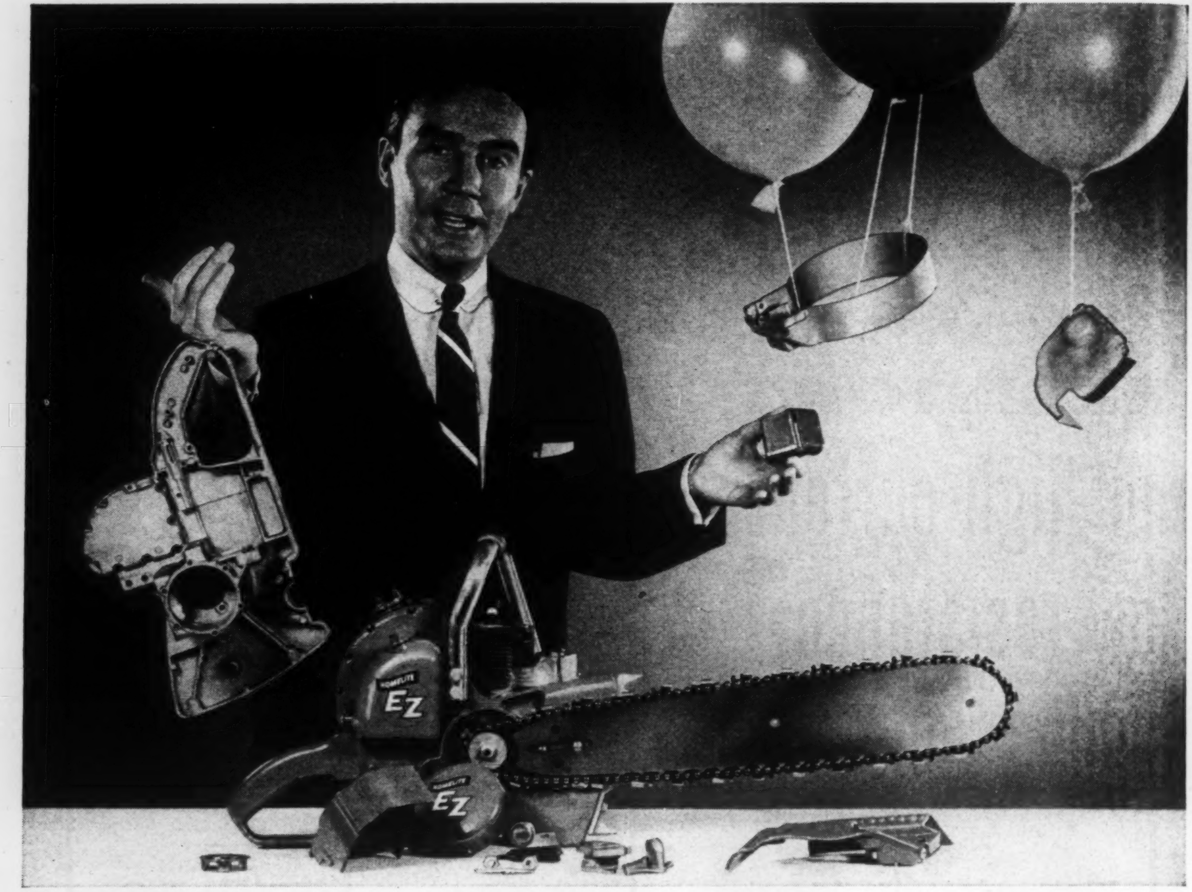


*Be Right with* **OHMITE®**

**RHEOSTATS**
**RESISTORS**
**RELAYS**
**TAP SWITCHES**
**TANTALUM CAPACITORS**

**OHMITE MANUFACTURING COMPANY,** 3618 Howard Street, Skokie, Illinois (Suburb of Chicago)

*Circle 551 on page 19*



## "So light, toy balloons can lift them..."

# Bantam-weight Doehler-Jarvis Homelite pack 5 horsepower

**The gasoline-engine-driven EZ is an eager little beaver . . . whips through an 18-inch pine in 14 seconds, an 8-inch oak in 5.**

This just shows that magnesium die castings are the lightest of light.

And they are amazingly strong.

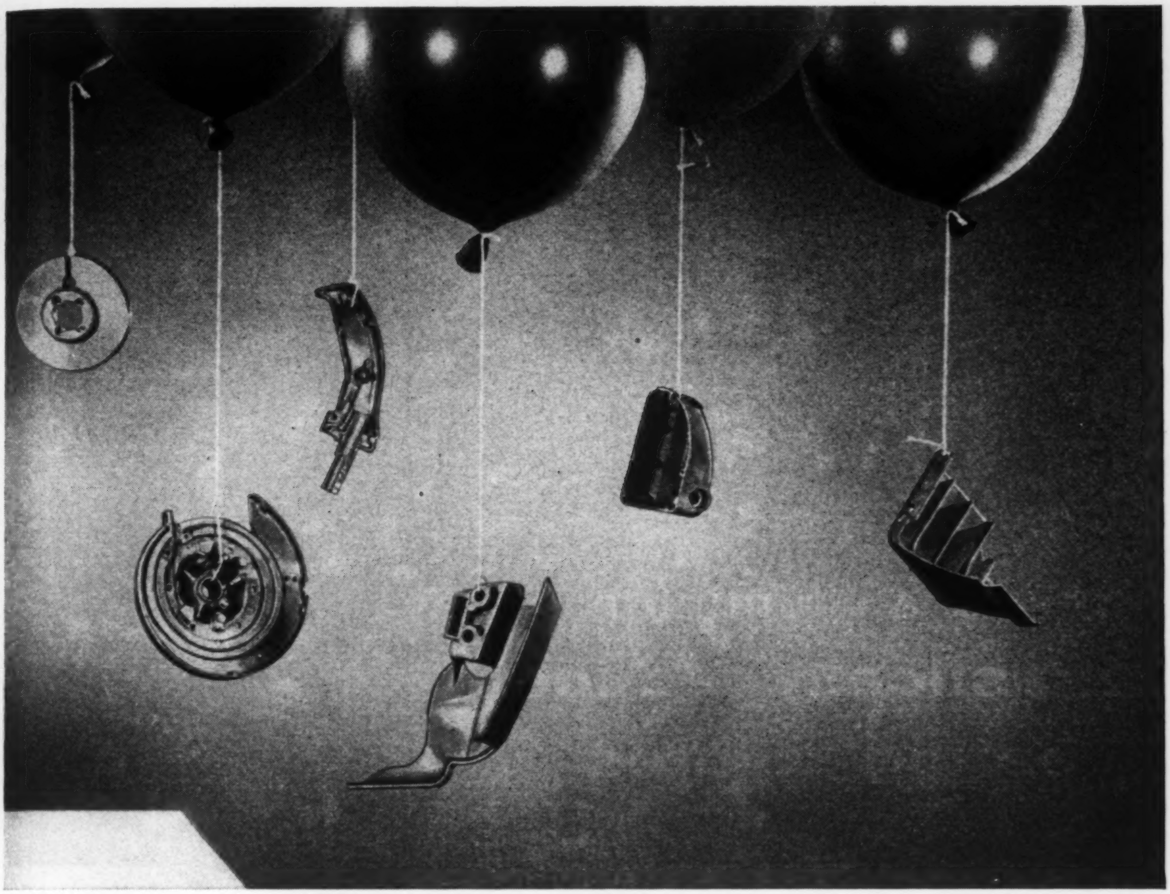
With these particular Doehler-Jarvis magnesium die-castings, for example, Homelite (division of Textron Inc.) packs 5 horsepower into their heavy-duty EZ direct drive chain saw and still keeps weight down to 19 pounds.

### Design aids lightness, too

This sales-building lightness and strength is not based solely on the use of magnesium. Homelite and Doehler-Jarvis engineers also eliminate practically all excess metal. They do this by taking advantage of minimum thickness die-cast sections. Ribs provide rigidity.

They do away with much machining, too. And cast in several competitive advantages. For example:

- Die casting establishes accurate machining base points. These permit multi-jig production and both improve



# magnesium die castings help into this 19-pound chain saw

dimensional accuracy and reduce cost.

- Servicing instructions in bas-relief are die-cast right into certain parts.

What's more, Doehler-Jarvis delivers the raw parts with near perfect "as cast" surfaces... surfaces that need only degreasing to accept a high-quality finish.

### PA reports outstanding service

EZ sales got off the ground fast. Within weeks Homelite needed twice the projected quantity of castings. With a separate plant at Batavia, N. Y. for producing magnesium die castings, Doehler-Jarvis was able to respond quickly. Says Homelite's Purchasing Agent, "Those fellows out in Batavia have certainly done an outstanding job for us."

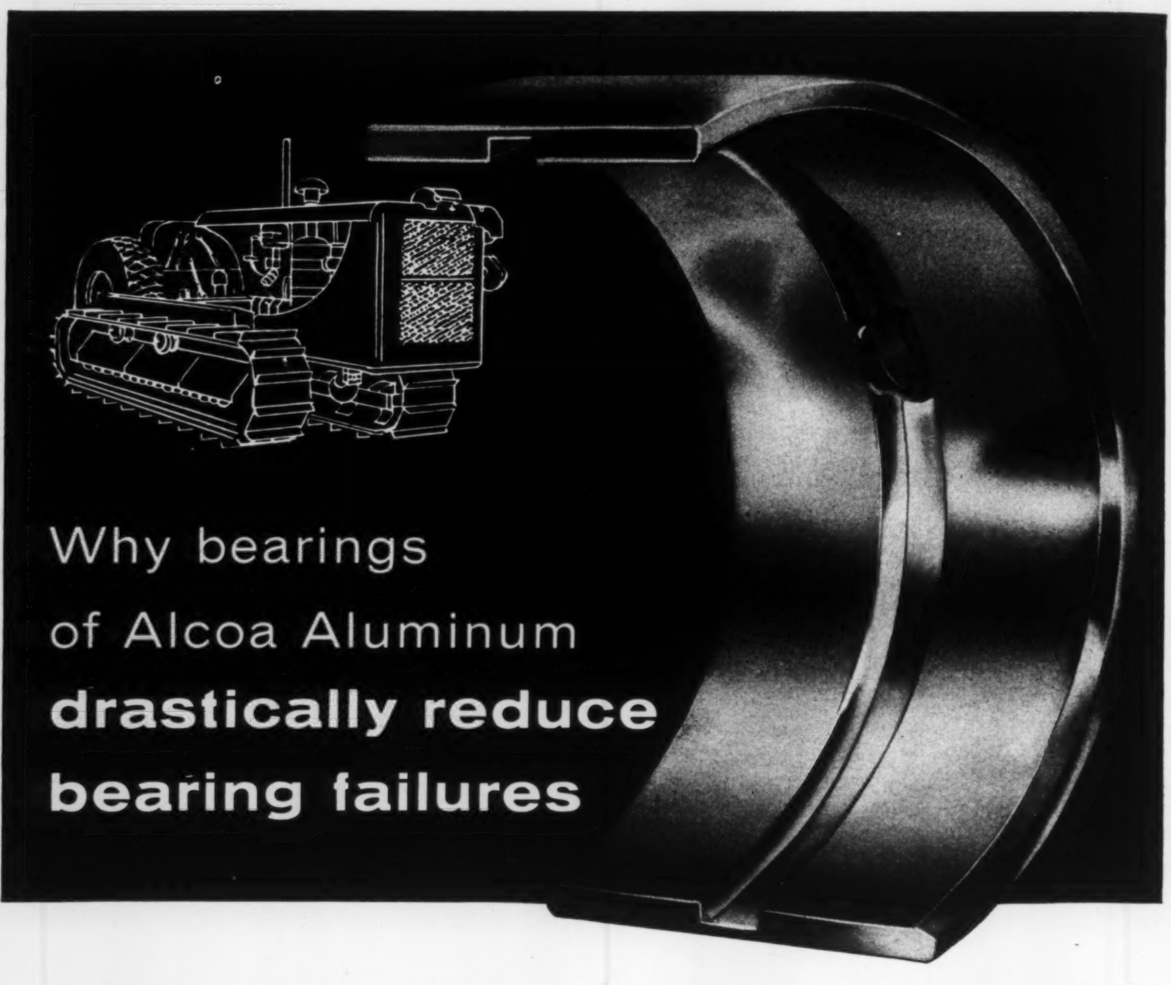
And you can be sure that Doehler-Jarvis *does* do outstanding work. Right now we're operating some 20,000 dies for some 1400 firms. Call us in on *your* next job.

**Doehler-Jarvis**
**DIVISION OF NATIONAL LEAD COMPANY**
General Offices: Toledo 1, Ohio

In Canada:
**Barber Die Casting Co. Limited**
Hamilton, Ontario

® DJ DOEHLER-JARVIS

*Circle 552 on page 19*



# Why bearings of Alcoa Aluminum **drastically reduce bearing failures**

A major implement company switched to solid aluminum for main connecting rod and thrust bearings in tractors. Result: a *drastic* reduction in bearing failures . . . *much* longer bearing life.

In hundreds of different kinds of applications solid aluminum bearings are outperforming bronze and babbitt because aluminum has an *unmatched combination of advantages.*

**Highest load capacity**—No other material is in the same league with aluminum for load-carrying capacity—up to 10,000 psi on projected area. Only aluminum can be used for solid bearings in heavy-duty service.

**20° cooler running**—There's less chance of seizure with aluminum bearings—they run up to 20° cooler than others.

**Excellent conformability**—Aluminum is a very ductile metal, conforms readily to misalignment or nonparallelism.

**Handles dirt well**—Aluminum embeds dirt particles better than bronze but not as deeply as babbitt. Dirt rolls out easily and into the filter.

**No corrosion problem**—Oil additives don't hurt aluminum bearings. No protective coatings are needed.

**No failure damage**—With solid aluminum bearings there is, of course, no hard backing material to damage the shaft in event of bearing failure.

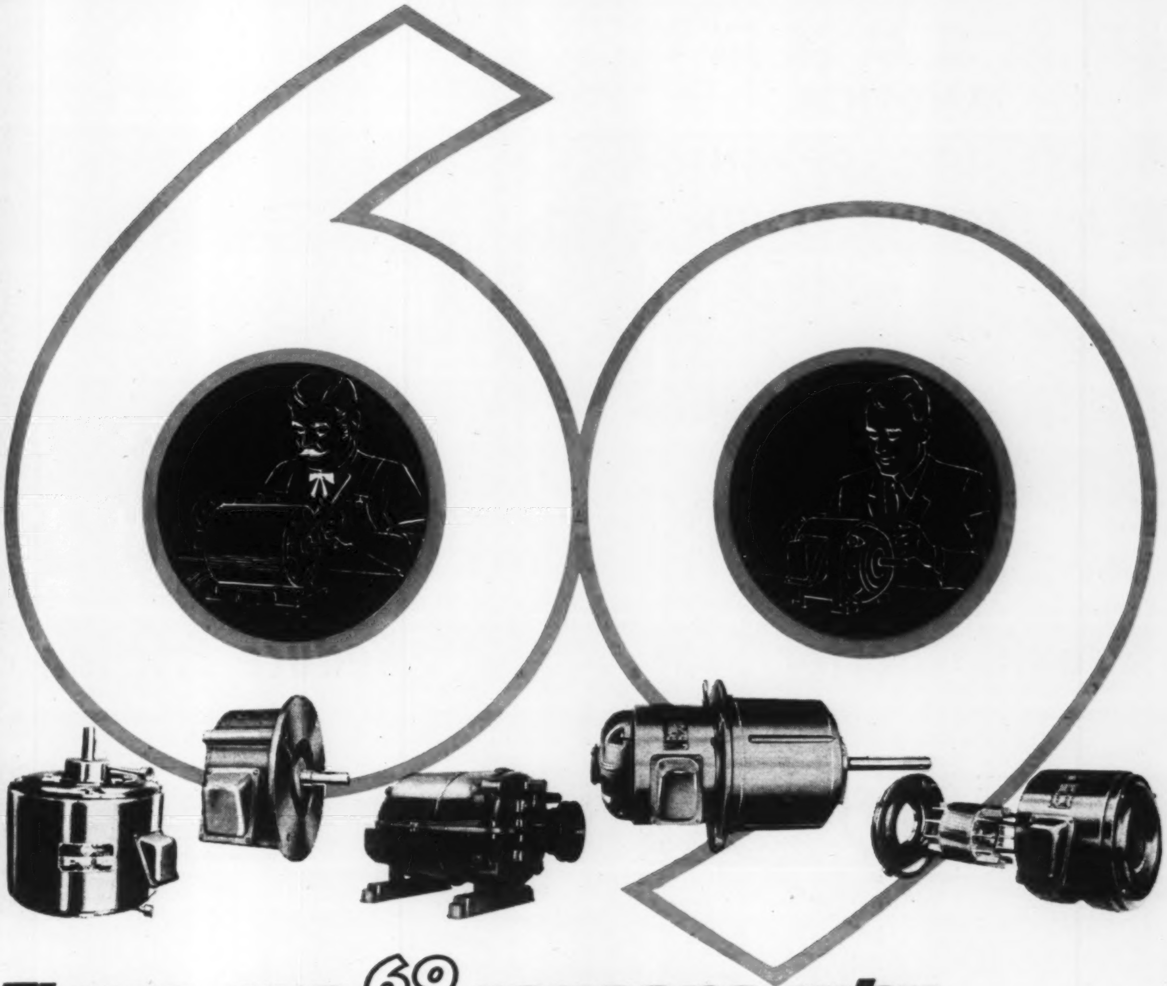
**Great design flexibility**—Aluminum bearing alloy is also a *structural* material so you can do such interesting things as designing rocker arms and connecting rods that need no bearing inserts, or water-cooled bearings with integral cooling passages.

Find out more about cast bearings of solid Alcoa® Aluminum. Check your bearing manufacturer or write: Aluminum Company of America, 1986-M Alcoa Bldg., Pittsburgh 19, Pa.

**THE ALCOA HOUR**
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

WE CHOSE
ALCOA ALUMINUM
MILL PRODUCTS
ALUMINUM COMPANY OF AMERICA

*Your Guide to the Best in Aluminum Value*



# There are 69 reasons why

—Diehl can build better motors. For 69 years, successive generations of Diehl motor specialists have applied their accumulated know-how to solving the power problems of widely divergent types of industries. In the smallest shops or the largest plants—all over America—Diehl men study the problem along with the customer. Name your motor requirements—no matter how "different," it's more than likely that an almost-similar situation has been recently brought to a successful conclusion with Diehl action. Here's where Diehl know-how helps you. The right answer and the right motor—*at the most reasonable cost*—can be yours, fast! Designed and built for your job. Get all the power and get it right—from Diehl.

*You invest in Performance*

**when you design with DIEHL.**

INTEGRAL AND FRACTIONAL HORSEPOWER MOTORS ARE AVAILABLE IN A WIDE RANGE OF TYPES AND SIZES

Diehl

DIEHL MANUFACTURING COMPANY
**Electrical Division of THE SINGER MANUFACTURING COMPANY**
**Finderne Plant, Somerville, N. J.**

MD

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Company____________________

Street____________________

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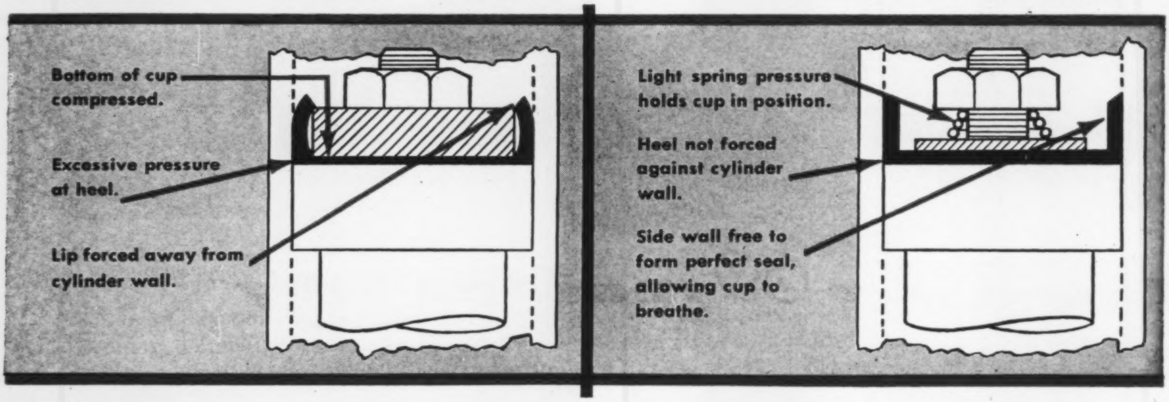
*Circle 554 on page 19*

**ANOTHER**
**NEW DEVELOPMENT**
**IN PACKING DESIGN**

# SPRING MOUNTED CUPS

## *Provide Better Seal........Reduce Friction*


Bottom of cup compressed.
Excessive pressure at heel.
Lip forced away from cylinder wall.
Light spring pressure holds cup in position.
Heel not forced against cylinder wall.
Side wall free to form perfect seal, allowing cup to breathe.

Houghton hydraulic research has come up with one of the chief answers to the problem of excessive friction, short cup life and chatter so often encountered in cup packing installations. Now, instead of the squeezing action of bolting the cup packing in place between the piston and the follower plate, you can use a spring mounting with preformed cup packings. The illustrations show the obvious advantages.

This leadership in hydraulic know-how is typical of Houghton, which makes all types of hydraulic and pneumatic packings, as well as a complete line of hydraulic oils and fluids.

Standardize on Houghton. You'll get the newest first—and the best always. Call your Houghton Man. He will explain their Hydraulic Service. E. F. Houghton & Co., 303 West Lehigh Avenue, Philadelphia 33, Pa.

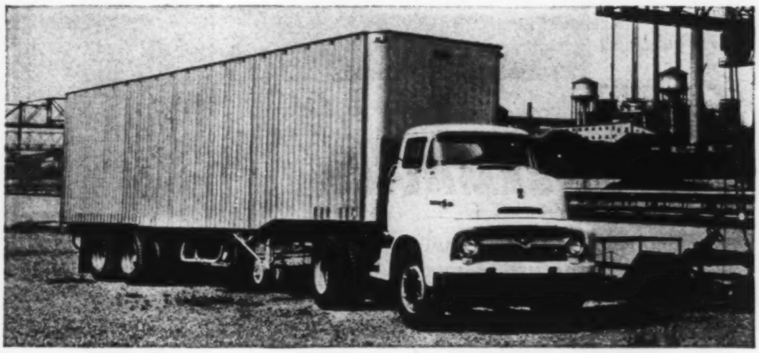
**. . . products of**

**E. F. HOUGHTON & CO.**
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

***Ready to give you on-the-job service . . .***

Rolling up the Miles

AMBASSADOR BRIDGE



Rolling Down the Costs

**Write for your copy of "STAINLESS STEEL IN PRODUCT DESIGN"**

40 pages of useful engineering and fabricating data, including practical examples showing where, when and how stainless steel improves design, adds benefits, helps sales.

**ADDRESS DEPT. MD-84**

Ask any user: stainless steel trailers *do* roll up extra miles. In fact, they can roll indefinitely because of their great strength and resistance to rust and wear . . . qualities in which *no other metal* matches stainless steel. Of course, that longer operational life means lower over-all expense.

But stainless helps roll down the costs (and UP the profits!) in other ways. It's so strong that thin-wall sections and structural members can be used, permitting greater payload capacity and offering additional savings in operating expenses. Painting isn't needed, and maintenance is cut to a whisper.

Such properties make stainless steel an ideal material for trailers, trains, planes, etc. They qualify it for myriad other applications, too. Chances are that *you* could use it when your product (or process equipment) requires superior strength, corrosion resistance, heat resistance, sanitary qualities, ease of fabrication, durability and attractiveness. ● We'd be pleased to discuss it with you—anytime you say or anywhere you'd like to meet. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

WSW 6062 B

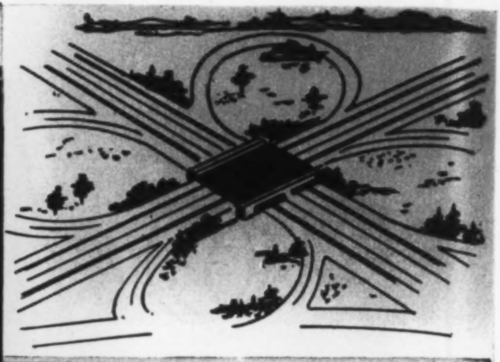
**Make it BETTER-and LONGER LASTING-with**

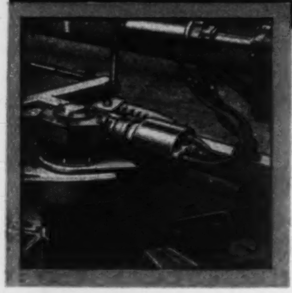
**AL Stainless Steel**

AL ALLEGHENY LUDLUM ®

Warehouse stocks carried by all Ryerson Steel plants

Circle 556 on page 19





GALION 104 Motor Grader, above, uses Eastman Assemblies on *EIGHT* Hydraulic controls for more accurate, effortless and economical grading. Close-up, left, shows powerful Hydraulic Circle Turn for famous Galion "Reversible" Moldboard.

BARBER-GREENE Bituminous Finisher, right, automatically lays level finish for smoother, safer travel. Close-up shows Eastman Hydraulic Hose Assembly delivering 2,700 lbs. pressure to raise and lower finishing screed.

# *Smoother, Safer Roads*

**BUILT WITH HYDRAULIC POWER**
**DELIVERED THROUGH**

# Eastman

## *HYDRAULIC HOSE ASSEMBLIES*

**COUPLINGS**

Solid Male
Swivel Male
Swivel Female
STRAIGHT AND ANGLED ADAPTER UNIONS
Straight Male
90° Male
45° Male

**ALWAYS SPECIFY**

EASTMAN Pressed-on, Reusable and Renewable Couplings for high and low pressure air, gas, water, paint, grease and hydraulic fluids. Eastman Straight and Angled Adapter Unions.

Smoother, safer highways are being built today through the application of modern engineering and the use of modern equipment—much of which is hydraulically operated—using Eastman Hydraulic Hose Assemblies.

**GALION**—pioneer builder of road machinery—whose Motor Graders and Rollers are used 'round the world—first used hydraulic controls as early as 1927. Eastman Mfg. Co. pioneered in the development of Hydraulic Hose Assemblies in 1926—and *Galion is Eastman equipped today!*

**BARBER-GREENE**—whose Bituminous Road Finishers have been used at one time or another on almost every road ever built—also uses Eastman Hydraulic Hose Assemblies. Hydraulic power is used to raise and lower the all-important mechanism which lays a level finish—regardless of irregularities in the base. Barber-Greene's founding date of 1916 closely parallels Eastman's of 1914—and *Barber-Greene is Eastman equipped today!*

**EASTMAN**—*first in the field*—is proud to have pioneers such as Galion and Barber-Greene—as well as many other leading American manufacturers—use Eastman Hydraulic Hose Assemblies. Look to Eastman for *continued leadership* in engineering and design for quality of material and workmanship—plus better-than-ever service through expanded production facilities of our new, modern plant.

SAFEGUARDING INDUSTRY'S *Lifelines of Mobile Power*

**Eastman**
*first in-the-field*
**MANUFACTURING COMPANY**
**Dept. MD 12, Manitowoc, Wis.**

BUILD BETTER ROADS TODAY FOR A GREATER AMERICA

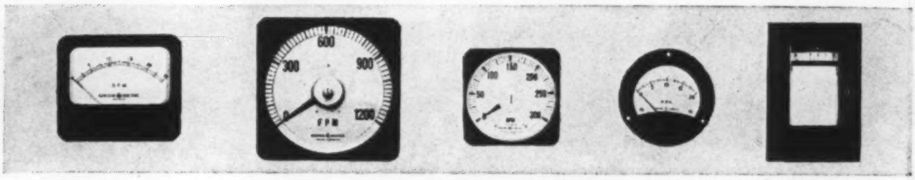
**See you at the ROAD SHOW CHICAGO**
**Jan. 28-Feb. 2, 1957**
**BOOTH NO. 359—SECTION A**
(North Hall, 2nd floor)

Circle 557 on page 19

*General Electric Speed Measuring Systems:*

# Handsome Appearance and Top Quality Increase Customer Acceptance and Resale Value

## G-E application engineering and fast shipment help you get the right system when you need it



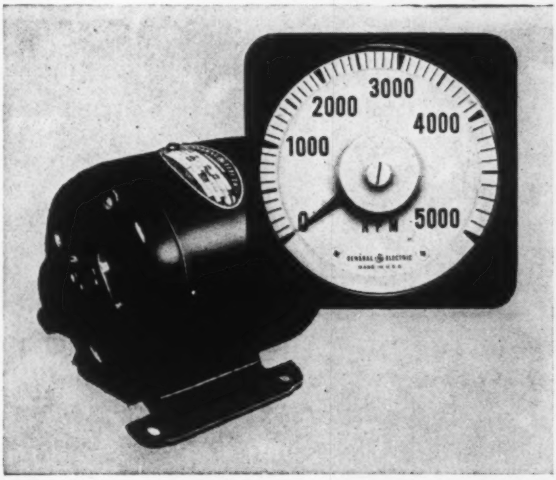
**COMPLETE LINE of indicators and recorders to choose from offers you the exact type speed measurement you require.**

General Electric speed measuring systems are offered in a complete line for every application; each system you buy is *tailor-made* to meet your requirements.

Here are 9 reasons why you get optimum performance for your investment with G-E speed measuring systems:

1. Handsome appearance of G-E indicators contributes to the good looks of your product and increases salability.
2. Top quality of every instrument assures you of extreme reliability under severe conditions.
3. High accuracy of ±1% of full scale is made possible by factory calibration of generator and indicator together.
4. Small size of both generators and indicators gives you greater latitude when selecting a mounting position.
5. Excellent readability of indicators is provided by long scales and large numbers. Non-parallax glass of DB-16 and DB-18 indicators allows reading from almost any angle.
6. Totally enclosed, both generators and indicators are fully protected from dust and dirt. Explosion-proof enclosures are available on some models.
7. Fast shipment of complete systems helps you meet commitments.
8. G-E application engineering is available to you on request to help you solve your speed measuring problems and select the proper equipment.
9. Any legend you require will be marked on your G-E tachometer indicator scales. Your instruments may be calibrated in units such as feet per minute, inches per minute, spindle rpm or any related speed. Manufacturer's or customer's name may also be imprinted on the scale face.

If you would like additional information on General Electric's complete line of speed measuring systems, call your nearest General Electric Apparatus Sales Office or write for Bulletins GEC-1258 and GEA-6427 to Section 585-57, General Electric Company, Schenectady 5, New York.



**EXCEPTIONAL ACCURACY is made possible because generator and indicator are calibrated as a unit at the factory.**

**GENERAL ELECTRIC**

Circle 558 on page 19

Circle 559 on page 19→

# GENERAL ELECTRIC ANNOUNCES

# static switching systems

General Electric's new static switching systems have been designed to increase significantly the dependability and life of control equipment where frequent operations, complex systems, and continuous processes are required or atmospheric problems exist.

These new G-E systems utilize static-magnetic and solid-state devices to perform a variety of control functions normally accomplished by contact-making devices. Static switching systems consist of varied combinations of seven basic units: an isolation switch unit, two multi-purpose units, a long time-delay unit, a short time-delay unit, an "AND" unit, and an "OR" unit. These units can also be combined with static power supplies, static amplifiers, and static regulators to provide completely static control systems.

**Where frequent operations are involved,** static switching systems are ideal, as they have no moving parts to wear.

**Where complex control functions are required,**the simplified circuitry of the static switching systems makes them particularly applicable.

**For continuous processes,** these systems assure dependability through the use of pre-tested, industry-proved static components.

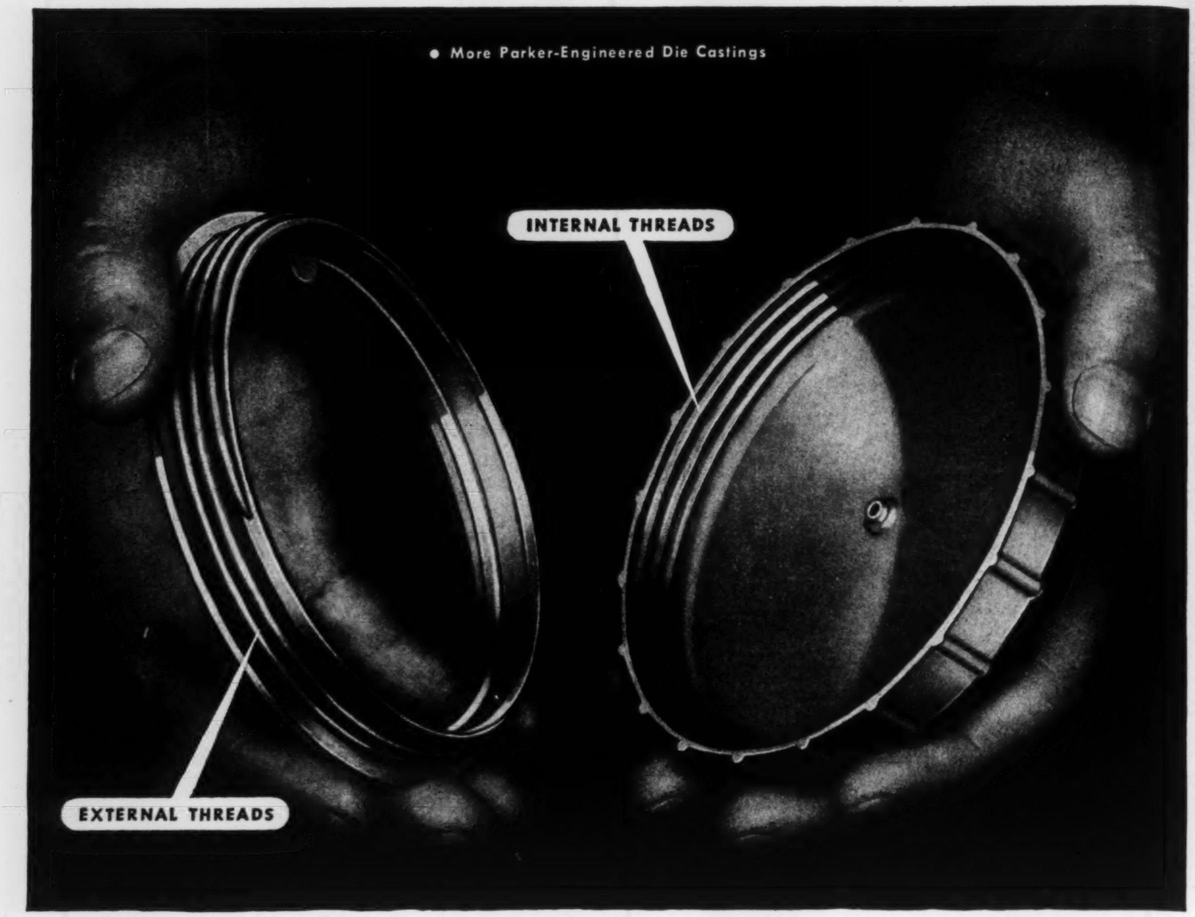
**Unaffected by most atmospheric conditions,** the static units are encapsulated in an inert, lightweight compound.

General Electric control engineers are ready now to help you apply the benefits of static switching systems to your machines or processes. For additional information, contact your nearest General Electric Apparatus Sales Office, or write for Bulletin GEA-6364 to Sect. 785-2, General Electric Co., Schenectady 5, New York. *Industry Control Dept., Roanoke, Virginia.*

*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**

2311100 G1



# From ONE Die: TWO Parts . . . THREE Savings!

## PARKER SALES ENGINEERS

**CHICAGO 49, Ill.**
Ollie J. Berger Company • 2059 East 72 Street
**CINCINNATI, Ohio**
William H. Broxterman • 2174 Buck Street
**DETROIT 35, Mich.**
Hodgson-Geisler Co. • 18917 James Couzens
**GIRARD, Penna.**
Daniel F. Marsh • 35 Chestnut Street
**KIRKWOOD 22, Mo.**
Edward F. Higgins, Jr. • 102 West Adams Street
**WILTON, Conn.**
Girard L. Palmer • Belden Hill Road
**SYRACUSE, N. Y.**
J. C. Palmer • 712 State Tower Bldg.
**BELLEFONTE, Penna.**
Warren G. Olson • 420 East Linn Street

These two mating parts, including the threads, are cast simultaneously in the same die. The result—three savings:

1—One die instead of two *saves die cost*

2—Casting two parts at one time in the same die *saves production time*

3—Precision casting of the perfectly mated threads with no parting line *saves machining cost*

Together, these three savings result in a substantially lower cost per piece. Just another example of the way Parker-engineered die castings save you money.

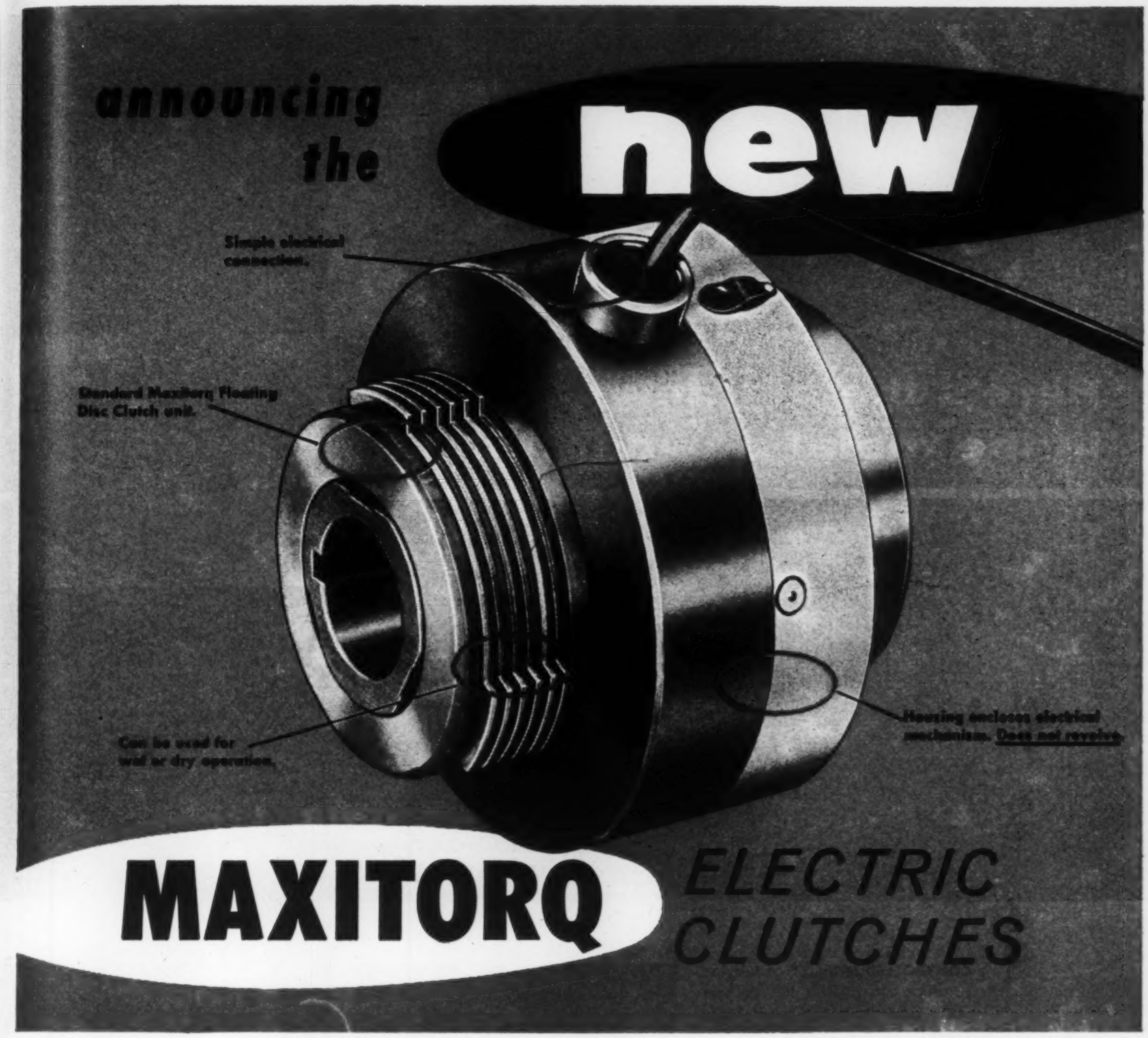
Parker has been a leader in die casting for over 50 years—an old hand with new ideas. This skill and experience can solve problems — and save money—on *your* component parts. Just call the nearest Parker sales engineer or write the factory direct.

**Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania**

**PARKER**

**high pressure**
**ALUMINUM and ZINC**
**die castings**
**POWDERED METAL PARTS**

*Circle 560 on page 19*


announcing the
new
Simple electrical connection.
Standard Maxitorq Floating Disc Clutch unit.
Can be used for wet or dry operation.
Housing encloses electrical mechanism. Does not revolve.
MAXITORQ
ELECTRIC CLUTCHES

Here is an entirely new series of clutches combining, in a single compact unit, all of the PROVED advantages of MAXITORQ Floating Disc Clutch design with an exceptionally simple, powerful, and dependable electro-magnetic actuating mechanism.

As will be seen from the illustration, the new clutches use standard proved MAXITORQ Disc-Pacs, quickly and easily replaced. The electro-magnetic unit is enclosed in a stationary housing, permitting direct wiring connection. When energized, the magnetic coil acts through an armature plate and sleeve to exert pressure on the clutch discs. Pressure, however, is maintained entirely by the magnetic flux, without mechanical contact between moving and stationary parts.

This unique design permits instant, positive engagement or disengagement, with the additional possibility of precisely controlling torque for a gradual pick-up or release of load. In addition to meeting standard clutch and brake installation requirements, MAXITORQ Electric Clutches open up new possibilities in application to fully automated equipment and for remote control.

Standard sizes, single and double types, are available for either wet or dry operation to transmit up to 788 lb. ft. of torque, operating on 110V–AC rectified to 90V–DC.

Complete details sent on request. Write Dept. **MD-12.**

- **PROVED** performance.
- **COMPACT** design.
- **FLOATING** neutral . . . no drag.
- **POSITIVE** engagement.
- **STATIONARY** coil . . . no brushes.
- **NO ADJUSTMENT.**
- **WET OR DRY** operation.
- **FULL** power transmission.
- **FULL** range of sizes, types.

**THE CARLYLE JOHNSON MACHINE COMPANY**

MANCHESTER, CONNECTICUT

6CJ56

Circle 561 on page 19

# Here's the big news in the metal powder industry

**CONTROLLED QUALITY** of tubular products starts with the carbon steel and stainless steel from which they are made. Republic ELECTRUNITE® Tubing is controlled for quality from ore to finished tubing. When you specify ELECTRUNITE Tubing you are sure of getting uniform diameter, wall thickness, concentricity, strength and ductility. These characteristics back your production facilities, simplify and speed output of superior parts like the immersion heater being fabricated at right. Mail the coupon for complete information.

# REPUBLIC

REPUBLIC STEEL

*World's Widest Range of Standard Steels*

# REPUBLIC IRON POWDER with

# Controlled Dimensional Factor

The Metal Powder Division of Republic Steel is now producing three types of Iron Powder, each with a variable controlled characteristic. This is called *Controlled Dimensional Factor*.

Simply stated, it means that in the presence of copper, Republic Iron Powder—depending on type—can be made to grow, shrink or remain stable within acceptable limits. The powders have been designated as Type S for shrinkage, Type G for growth, Type N for normal.

Think what this means to you as a producer or designer of iron powder parts. For example, suppose your dies have become oversize through wear. By using Type S powder, with a controlled shrinkage factor, you can continue to use those dies and still produce parts to specified tolerances.

*Controlled Dimensional Factor* is exclusive with Republic and the Republic production process. CDF is an addition to the excellent Republic chemistry. CDF powders are also available with apparent density ranges of 2.3 to 2.5.

For engineering service or more information on how CDF can be applied to your production of iron powder parts, send the coupon.

←

**CONTROLLED PHYSICAL PROPERTIES** and the cold finishing process performed on Republic Cold Drawn Steels provide dependability and economy in the manufacture of hinge pins and pivot ends on the Sherman Digger. Republic Cold Drawn Steels give these parts higher strength, greater hardness and a bright, smooth finish. They also provide top ratings on feeds and speeds, long tool life, freedom from abrasion and high product quality. Available in all carbon, alloy and stainless analyses.

→

**CONTROL COSTS** on your stamped and drawn parts by using the top-notch production facilities of Republic's Pressed Steel Division. This truck pedal shaft bracket is one of a wide variety of steel parts mass-produced for large-volume manufacturers. Large or small, we handle them all. Your savings in handling, inventories, labor and overhead are reflected in reduced cost per piece. Booklet 681 describes the entire operation. Send the coupon.

**REPUBLIC STEEL CORPORATION**
**Dept. C-2217-A**
**3130 East 45th Street**
**Cleveland 27, Ohio**

Send more information on:
☐ Iron Powder ☐ ELECTRUNITE Tubing
☐ Cold Finished Steels ☐ Stampings

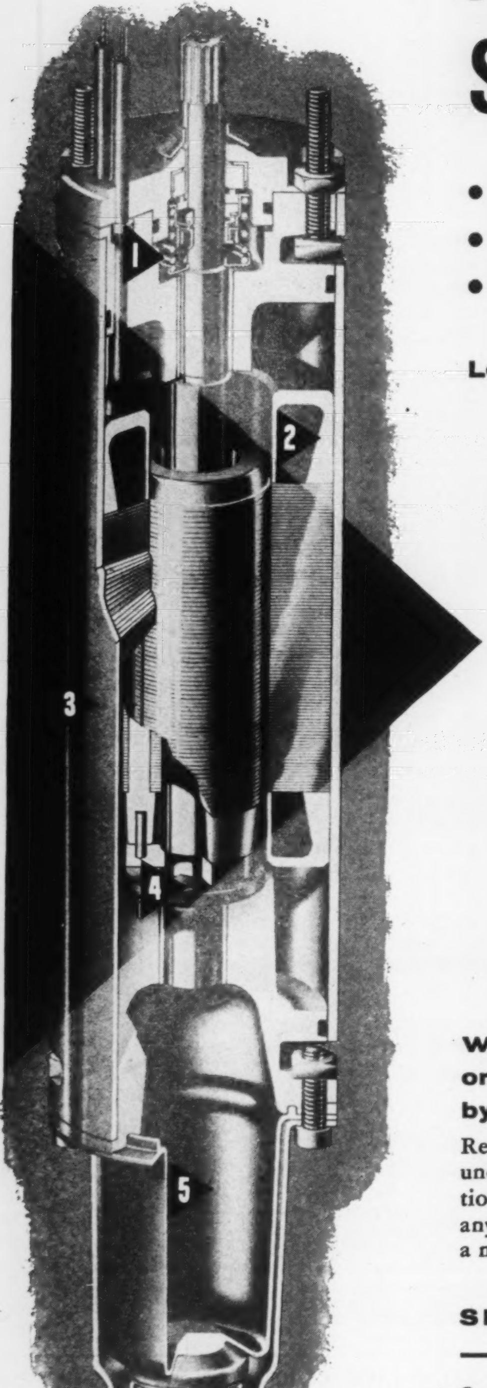
Name__________ Title__________
Company__________
Address__________
City__________ Zone____ State__________

# STEEL

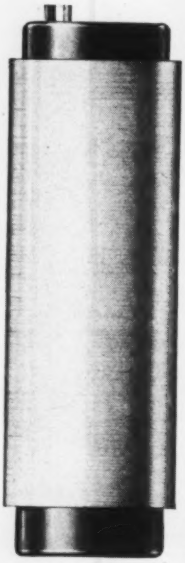
*and Steel Products*

# Announcing a *CUSTOMIZED*
# SUBMERSIBLE MOTOR

- **that fits in a small-diameter casing**
- **that gives you high output**
- **that runs in water, oil or other fluids**



## Look at typical features of a J&H Underwater Motor



**1** *Rotary Seal*—Ceramic and graphitar faces, carefully lapped to insure against entry of water and contaminants.

**2** *Encapsulated Windings*—A special J&H epoxy compound is used for "potting." Epoxy has exceptional heat conductivity and does not buckle or swell under many abnormal conditions. "Potting" prevents winding failure, even if water enters motor. In fact, motor will operate as water-filled unit.

**3** *Corrosion-resistant Epoxy Paint Finish.*

**4** *Segmented Tilting-shoe Self-aligning Thrust Assembly*—Ample reserve thrust carrying capacity is provided. Faces accurately lapped for long wear.

**5** *Oil-filled Motor*—A large reservoir of oil provides additional dielectric strength, insures longer seal and bearing life, protection against corrosion.

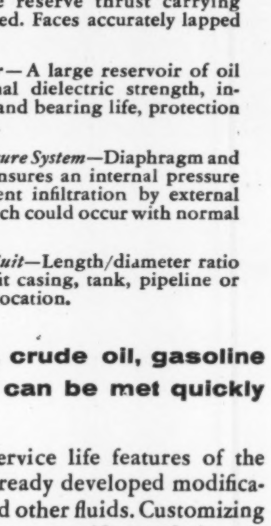
**6** *Controlled Pressure System*—Diaphragm and spring assembly insures an internal pressure sufficient to prevent infiltration by external contaminants, which could occur with normal seal wear.

- *L/D Ratio To Suit*—Length/diameter ratio can be varied to fit casing, tank, pipeline or other designated location.

## Whether you're pumping water, crude oil, gasoline or other fluids, your motor need can be met quickly by Jack & Heintz!

Retaining the size flexibility and long service life features of the underwater motors, J&H designers have already developed modifications for operation in crude oil, gasoline and other fluids. Customizing any of the proved basic designs to meet your specific needs is only a matter of defining your service and dimensional requirements.

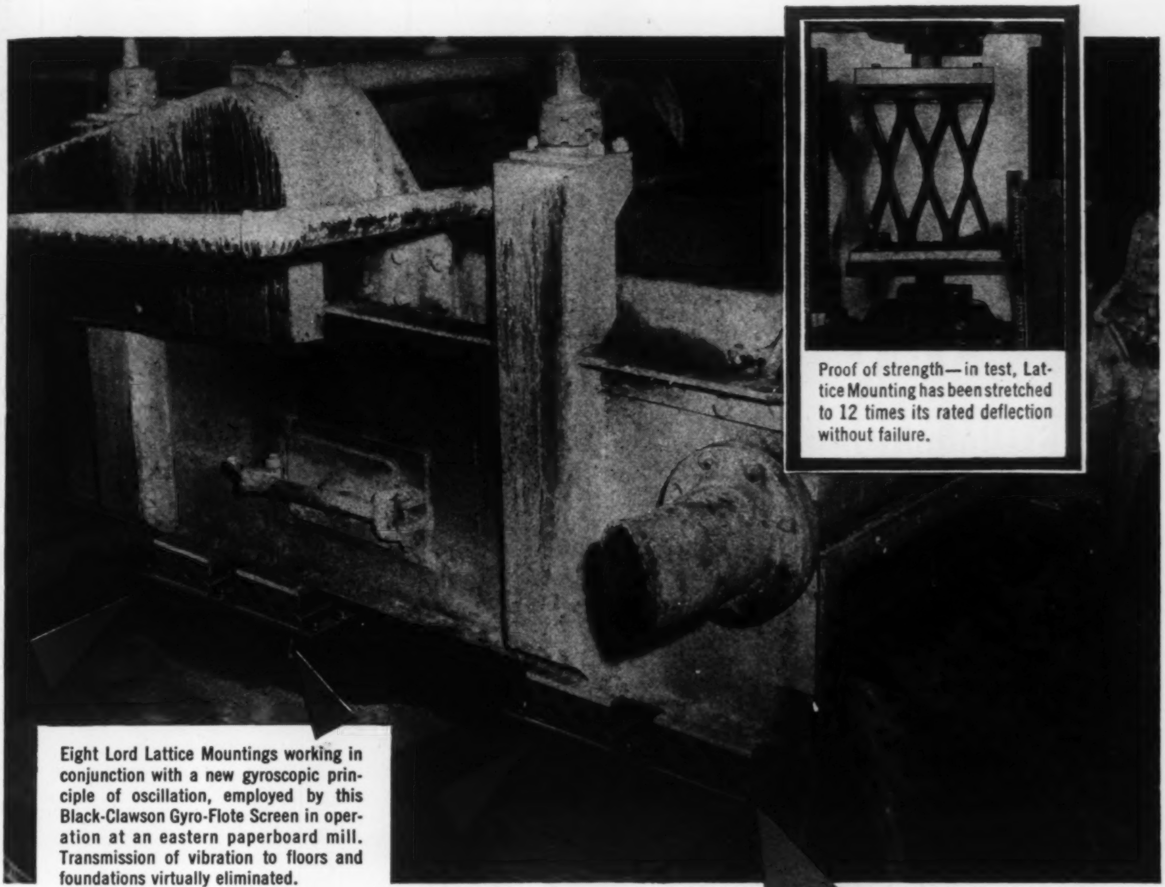
## SEND FOR DATA TODAY



Confer with J&H motor specialists or write for folder which gives rating and performance data: Jack & Heintz, Inc., 17626 Broadway, Cleveland 1, Ohio.

©1956 by Jack & Heintz, Inc.

**JACK & HEINTZ** ***CUSTOMIZED*** **ELECTRIC MOTORS**



Proof of strength—in test, Lattice Mounting has been stretched to 12 times its rated deflection without failure.

Eight Lord Lattice Mountings working in conjunction with a new gyroscopic principle of oscillation, employed by this Black-Clawson Gyro-Flote Screen in operation at an eastern paperboard mill. Transmission of vibration to floors and foundations virtually eliminated.

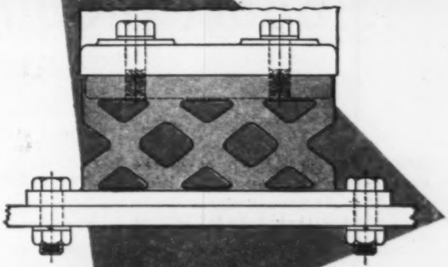
# how to isolate heavy-duty machinery vibrations

## LORD LATTICE MOUNTINGS PROVIDE FLEXIBLE SUPPORT— DAMPEN LOW FREQUENCY, HIGH AMPLITUDE VIBRATIONS

Efficiency-destroying machine noise and vibration can be effectively reduced by using Lord Lattice Mountings. Placed under vibrating machinery, they absorb intermittent or continuous pounding, protect performance. Installation is a simple bolting operation using tapped holes in the upper plate and through holes in the lower plate of the unit.

The patented lattice design of the flexing element, perfected by Lord research and engineering, provides soft spring rate characteristics in all directions with good horizontal stability. This element is permanently bonded to steel plates, forming a simple, one-piece unit that *never* requires maintenance.

Lord Lattice Mountings are available in load ratings from 250 to 3,000 pounds per mounting. A complete description is contained in Bulletin No. 701. For your copy, or other information, contact your nearest Lord Field Engineer or write the Home Office, Erie, Pennsylvania.



Installation diagram shows how Lattice Mountings provide a flexible but rugged base for heavy [illegible] equipment. Installation of long-lasting mountings is easy and quick.

**LORD**

**BONDED RUBBER**

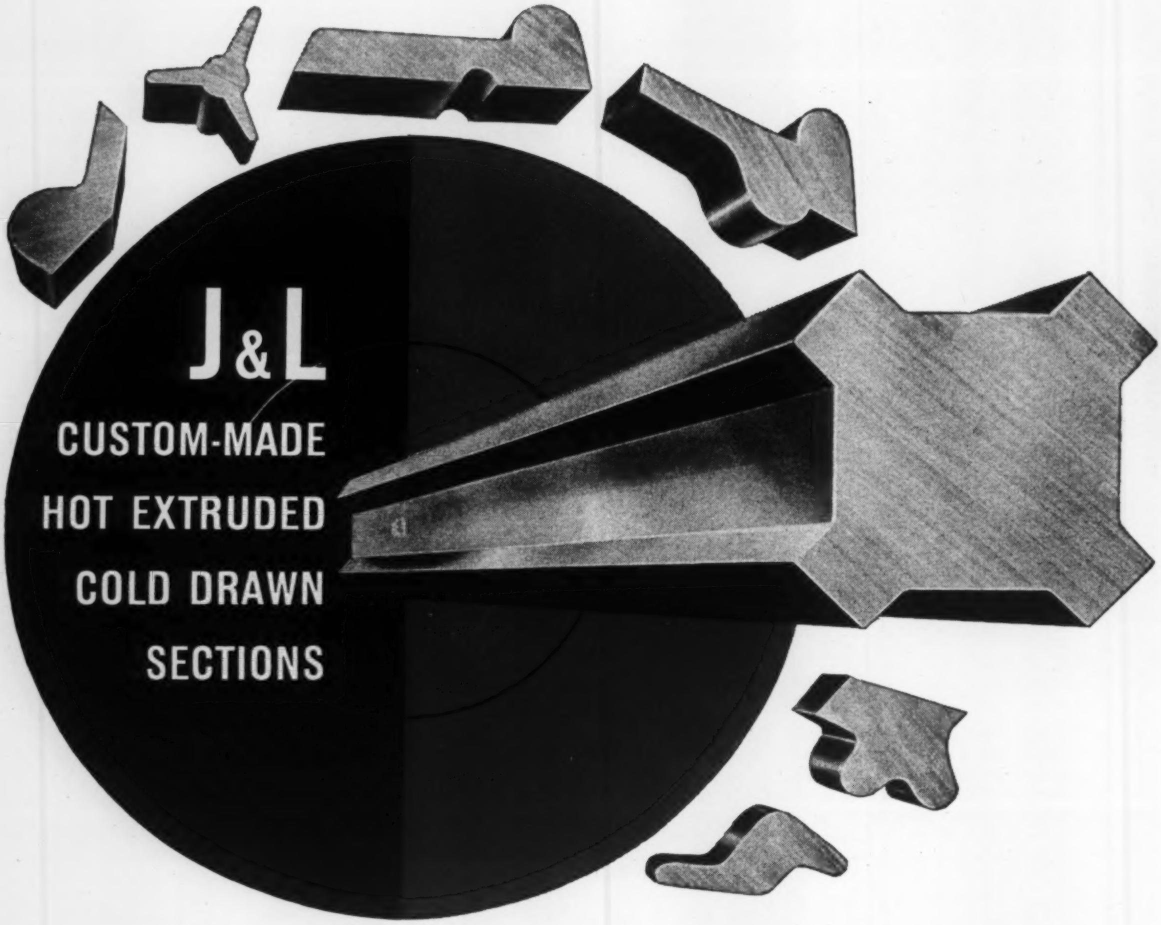
*designers and producers of bonded rubber products since 1924*

**Lord Lattice Mountings are covered by U. S. Patent Nos. 2322193 and RE22280.**

**LORD MANUFACTURING COMPANY • ERIE, PA.**

ATLANTA, GEORGIA - CEdar 7-1123
BOSTON, MASS. - HAncock 6-9135
CHICAGO, ILL. - MIchigan 2-6010
CLEVELAND, OHIO - SHadyside 9-3175
DALLAS, TEXAS - RIverside 3392
DAYTON, OHIO - MIchigan 8871
DETROIT, MICH. - TRinity 4-2060
LOS ANGELES, CAL. - HOllywood 4-7593
NEW YORK, N. Y. - Circle 7-3326
PHILADELPHIA, PA. - LOcust 4-0147

"In Canada—Railway & Power Engineering Corporation Limited"



# J&L CUSTOM-MADE HOT EXTRUDED COLD DRAWN SECTIONS

# ...boost production, cut over-all costs

AT YOUR SERVICE

J&L

EXTRUDED SECTIONS

... tailor made
to your specifications

1. YOUR

2. YOUR

3. YOUR

4. YOUR

STEEL

**WRITE TODAY** for your copy of this free new booklet which gives detailed information about the many money- and time-saving advantages J&L Extruded Sections offer you.

Jones & Laughlin Steel Corporation
3 Gateway Center, Dept. 410
Pittsburgh 30, Pa.

Please send me your new Booklet on Extruded Sections.

Name____________________

Title____________________

Company____________________

Street____________________

City____________________

Zone________State____________

Progressive industry is today utilizing J&L's Custom-Made, Hot Extruded Cold Drawn Steel Sections to:

1. **Eliminate time and costs** in machining and finishing operations
2. **Reduce scrap losses** practically to the zero point
3. **Eliminate the cost of castings and forgings** of intricate sections requiring considerable machining
4. **Reduce inventories** due to quick availability of extruded sections from the J&L plant

These sections can be extruded and cold drawn to the exact specifications of the parts you require—in any quantity you specify. Even the production of a single extrusion can be economical. Obtainable in a wide range of material grades, J&L Extruded Sections can be produced in a large variety of shape profiles—within limits of a design which can be inscribed within a two-inch circle. Many shapes that cannot be hot rolled are practical for the extrusion process.

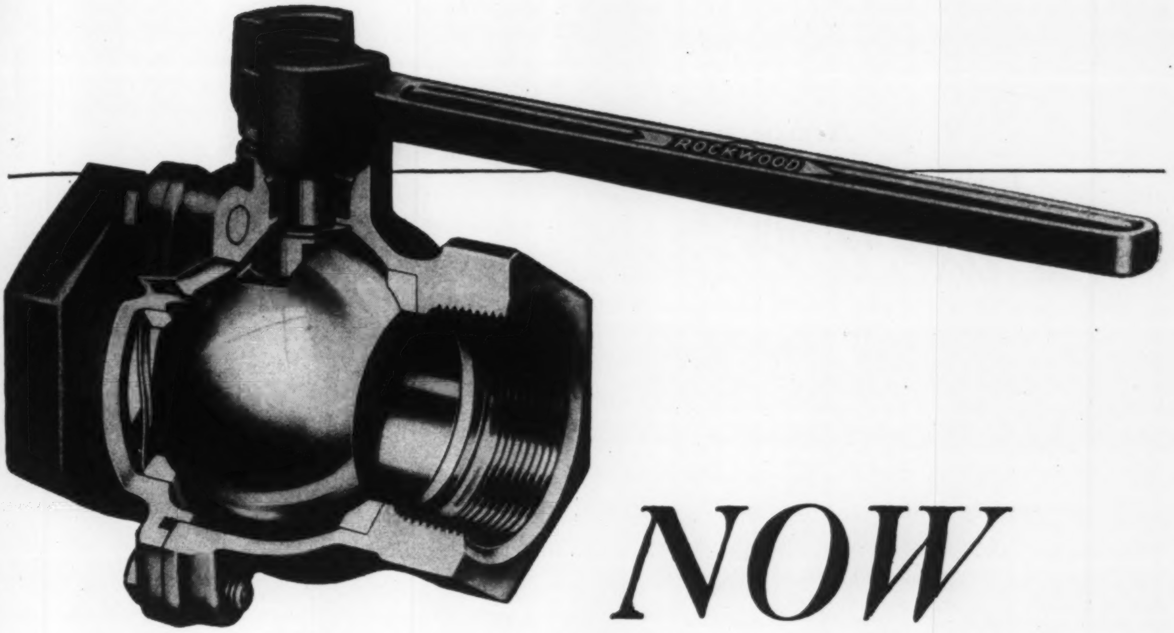
The mechanical properties of J&L Extruded Sections are equal to or superior to those obtainable from equivalent grades conventionally cold drawn. Cold drawn tolerances are accurately maintained. The excellent surfaces of these Extruded Sections require little—if any—finishing operations.

Send us your inquiry for prompt and efficient J&L service.

STEEL

**Jones & Laughlin**
STEEL CORPORATION · PITTSBURGH

*Circle 565 on page 19*



# *NOW*

# *a new STEAM valve with all the Rockwood Ball Valve advantages!*

The new Rockwood Bronze Ball Valve for use with steam offers you many unusual benefits.

**It Handles up to 125 Pounds of Steam** per square inch and 350°F, with ease.

**It's Leakproof** — even after continued use Rockwood Steam Ball Valves stay dry.

**It Opens and Closes Quickly** — only a quarter turn is needed to open or close Rockwood Ball Valves.

**It Has Longer Wear-Resistance** — chrome-plated bronze ball withstands abrasion, scratching and pitting.

Rockwood's new Ball Valve for use with steam comes in pipe sizes from 3/8" up to 2". Send coupon for full information and data. Distributors in all principal industrial areas.

## ROCKWOOD BALL VALVES

**FULL, ROUND FLOW**

ROCKWOOD

**ROCKWOOD SPRINKLER COMPANY**
**1227 Harlow Street**
**Worcester 5, Mass.**

Send me illustrated folder on Rockwood's new Ball Valve for use with steam.

Name.........................
Title...........................
Company.......................
City............Zone..State.....

Circle 566 on page 19

**AMPCO — ONE-SOURCE SERVICE FROM RAW MATERIAL TO FINISHED PRODUCT**

# Your Ampco field engineer has *no axe to grind* —when it comes to copper-base alloys

## Ampco supplies them all — and in any form of production

What does an alloy have to do for you? Resist wear, corrosion, impact, fatigue? Provide excellent bearing qualities? Retain physical characteristics at temperatures from 600°F down to −400°F?

Should it be sand-cast, centrifugally-cast, shell-molded, precision-cast, forged, fabricated, or extruded? Sheet or plate?

Whatever your design requires, your Ampco field engineer can help you . . .

1. Select the best alloy, from more than 100 Ampco copper-base alloys.
2. Select the best, most economical form of production.

Call in your Ampco field engineer.
And write for Bulletin 33.

**Metal for 4,000-pound casting** being poured into vertical-spindle centrifugal-casting machine. Ampco makes centrifugal castings in sizes up to five tons.

**Ampco's one-source service** includes production-run machining of Ampco copper-base alloys to the quality standards of the aircraft industry.

**Difficult coring problems** are solved every day in Ampco's modern sand foundry. Ampco produces sand castings in any size up to 14,000 pounds.

AMPCO®

***THE METAL WITHOUT AN EQUAL***

AMPCO METAL, INC. Dept. MD-12, Milwaukee 46, Wisconsin • West Coast Plant: Burbank, California

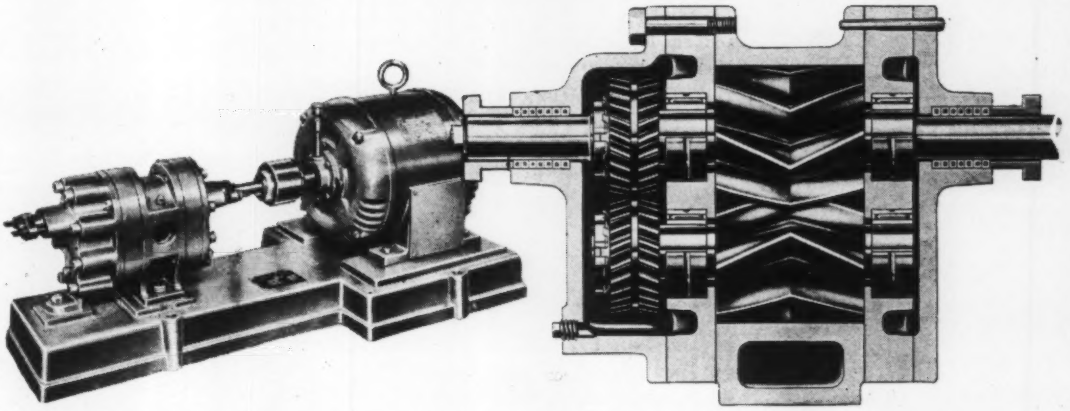
SHELL-MOULDED CASTINGS
CENTRIFUGAL CASTINGS
EXTRUSIONS
SAND CASTINGS
FABRICATIONS
SHEET AND PLATE
MACHINED PARTS
FORGINGS
CAST-TO-SIZE CASTINGS

Circle 567 on page 19

# ORANGE *Cage Type* NEEDLE BEARINGS

## meet strict design and operating requirements

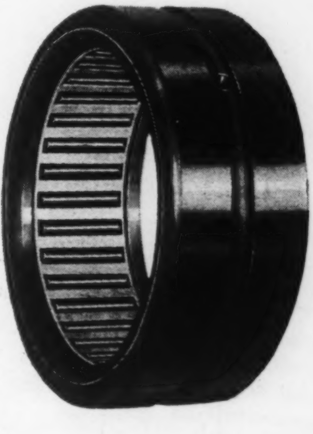
## in *Sier-Bath* "Gearex"® Pumps



**Sier-Bath "Gearex" Pumps (Internal Bearing Type) handle oils and lubricating materials from thin to heavy viscosities, in volumes up to 550 gpm. and pressures to 250 psi. "Gearex" Pumps are distinguished for compactness and high capacity—cool, quiet, vibration-less operation—dependability under severest 24-hour-a-day running.**

**Cutaway shows 4 Orange Cage Type Needle Bearings mounted on shafts of timing gears and double helical rotors. All parts and clearances are built to close tolerance and must be maintained through years of operation. The Orange cage-type bearings eliminate possibility of roller skewing—run smoothly, quietly—carry the loads in very small space—have been used successfully for eight years in this installation.**

## Non-skewing rollers – high capacity – small space provide answer to many bearing design problems



Don't lose the opportunity to compact your designs with the high load-to-space ratio of needle bearings because of specific or unusual operating conditions.

The unique advantages of Orange Cage Type Needle Bearings have broadened the use of needle bearings—opened many applications hitherto unsuited to conventional types.

With the Orange cage design, rollers are permanently aligned. The rollers can not skew. True running is assured at relatively high speeds and in any position—horizontal, vertical, tilted or overhung mountings. They are less affected by misaligned mounting or uneven loading. Operation is extremely quiet, even and trouble-free.

Standard sizes from ½″ to 8″ shaft diameters, with stocks and engineering service in all leading industrial centers. Write for 40-page Engineering Manual M-56 showing details and dimensions.

**ORANGE**
**ROLLER BEARINGS**

**ORANGE ROLLER BEARING CO., Inc.**
**556 Main Street, Orange, N. J.**

**Needle Bearings — Staggered Roller Bearings**
**Journal Roller Bearings — Thrust Roller Bearings**
**Cam Followers**

*Circle 568 on page 19*

Guarantee TOP Performance and Maximum Life!

# *Specify* THESE TOP QUALITY FEATURES...

## (Standard on Miller Cylinders at no extra cost)

*Specify* **CASE HARDENED CHROME PLATED PISTON RODS**
On all Air and Hydraulic Cylinders

***Benefits To You***

CASE-HARDENED Piston Rods (52-54 Rockwell "C") provide practically complete protection against damage from hammer blows, wrench-dropping, mishandling, and similar occurrences. *Available from Miller at no extra cost.*

The HARD CHROME PLATING over the case-hardened rods protects against scratch-damage and rust. *Available from Miller at no extra cost.*

*Specify* **"TEFLON" WIPERS**
On all Air and Hydraulic Cylinders

***Benefits To You***

"TEFLON" Rod Wipers and "TEFLON" Hydraulic Piston Rod Seals withstand temperatures from—100°F. to plus 500°F. They are impervious to practically all known chemicals, including the fire-resistant, special, and standard hydraulic fluids in current use. *Available from Miller at no extra cost.*

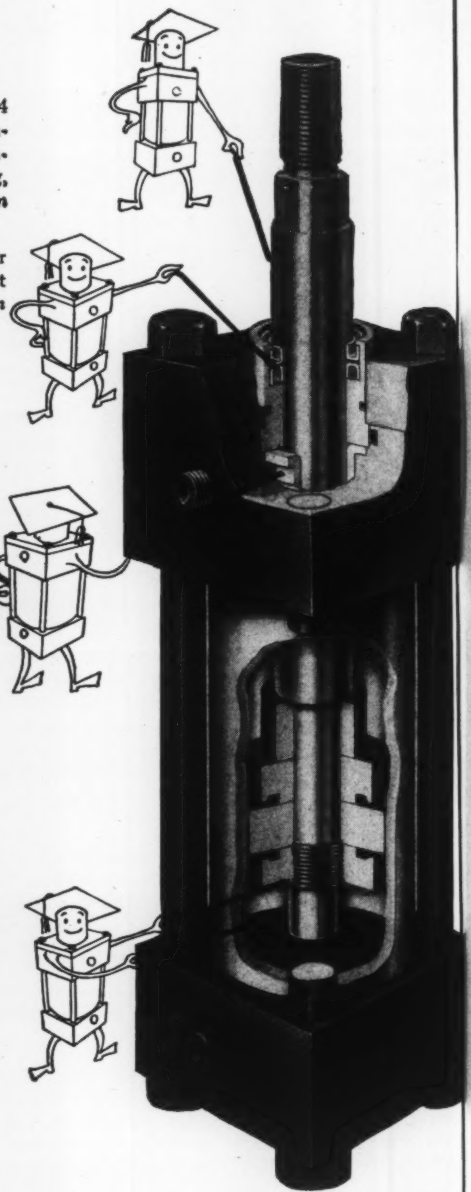
*Specify* **TEFLON HYDRAULIC ROD SEALS**
On all Hydraulic Cylinders

***Benefits To You***

Highest quality Black Ferric Oxide Finish provides rust protection in air cylinder operation and on all cylinders during shipping and installation.

Cylinder heads, caps, mountings, pistons, followers, tie rods, and the unplated portions of the piston rods have this finish *at no extra cost on all Miller cylinders.* (This finish not recommended for water service)

*Specify* **RUST RESISTANT SURFACES**
On all Air and Hydraulic Cylinders



*You may wish to route this entire page to the proper department in your company, by using this handy form. Additional copies on request.* →

To (Dept.)__________
"On all our future cylinder requirements, please specify the above quality features."
Signed__________
Title__________

**NOTE.** On all Miller Hydraulic Piston Seals: Leather Cup Seals are *standard,* Piston Ring Seals are optional *at no extra cost,* and "Teflon" Cup Seals are available *at extra cost.*

***Member of the National Fluid Power Association***

***SALES AND SERVICE FROM COAST TO COAST***

CLEVELAND • YOUNGSTOWN • DAYTON • TOLEDO • CINCINNATI • COLUMBUS PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY BUFFALO • ROCHESTER • MINNEAPOLIS • GRAND RAPIDS • DETROIT • FLINT FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • ATLANTA TORONTO, CANADA and OTHER AREAS

**MILLER FLUID POWER DIVISIO**
FLICK-REEDY COR

**2006 N. Hawthorne Ave., Melrose Park, Ill.**

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATO
COUNTERBALANCE CYLINDERS

***Circle 569 on page 19***

*Another new development using*

**B.F.Goodrich Chemical** *raw materials*

# HYCAR AMERICAN RUBBER CAN BE TAILORED TO YOUR REQUIREMENTS

***If this is your problem:***

You need a flexible material that is highly resistant to aromatic fuels, oils and solvent. The answer is Hycar 1041, a high acrylonitrile copolymer rubber—used in oil well parts, fuel cell liners, fuel hose, gaskets, O-rings, cements and adhesives. —***Hycar*** 1041

Your product needs to stand up in the presence of water, while also offering good oil resistance. Hycar 1042, a medium acrylonitrile copolymer, gives this combination—extremely useful for shoe soles, kitchen mats, sink topping and printing rolls. —***Hycar*** 1042

Or you must have a rubber that retains many of these other properties even at low temperatures. Hycar 1043 is a medium low acrylonitrile copolymer meeting these requirements, and easy to process. —***Hycar*** 1043

If low temperatures make your problem critical, Hycar 1014 may be the answer. It's a low acrylonitrile copolymer especially designed to emphasize this property. —***Hycar*** 1014

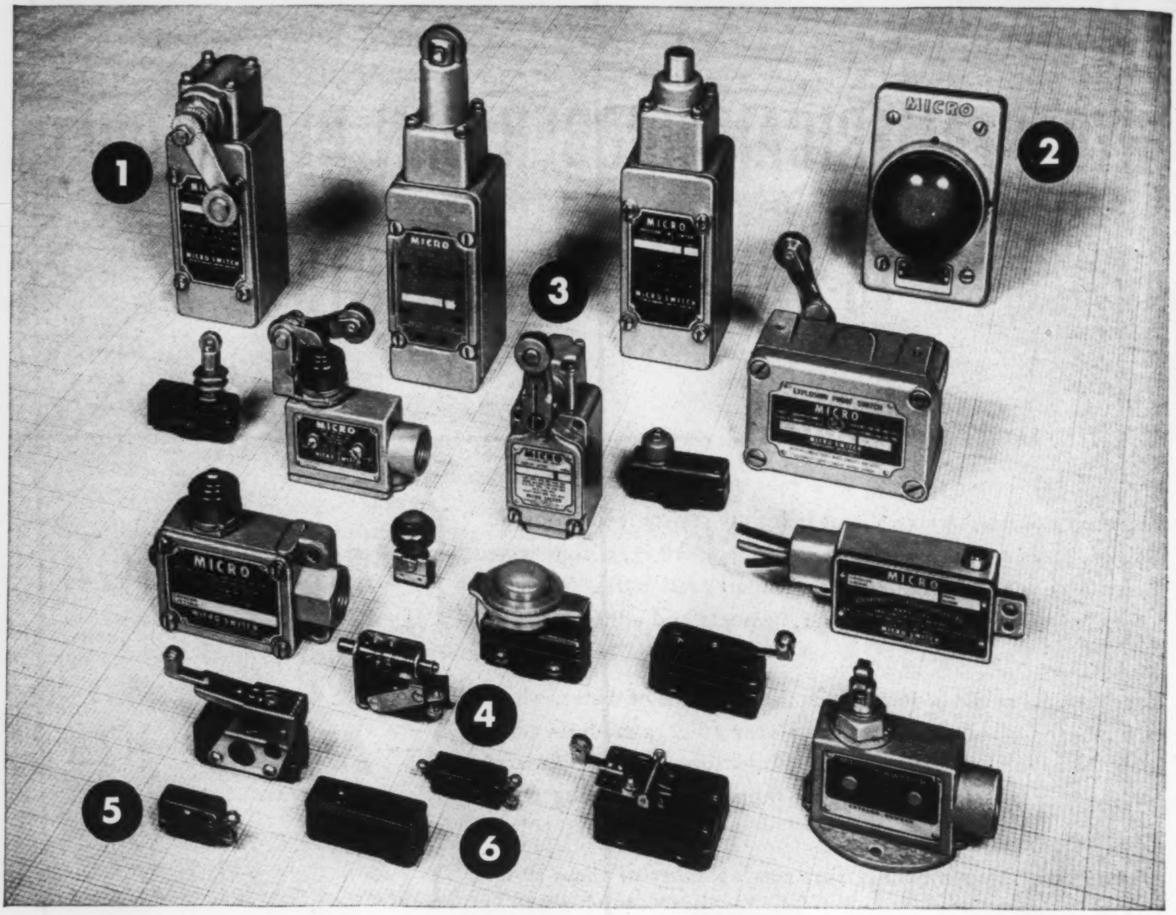
***These are but a few*** of the many Hycar American rubbers that are tailored to meet specific requirements. Literature is available listing the properties of standard materials. For copies write Dept. EJ-6, B. F. Goodrich Chemical Company, 3135 Euclid Ave., Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ont.

**Hycar**
Reg. U.S. Pat. Off.
*American Rubber*

**B.F.Goodrich** **GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors**

# MICRO precision switches

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN



## MICRO SWITCH Precision Switches meet the WIDEST RANGE of product design applications

MICRO SWITCH precision switches—a few of which are illustrated—are the switching mainstay of some of the most complex devices used in industry. They are important components in almost every type of electrically-operated equipment—from delicate instruments to massive machine tools.

*Product designers know from experience that they can count on—*

### MICRO SWITCH Quality

From raw materials to finished product, MICRO SWITCH precision switches are laboratory tested and quality-controlled at every step of manufacture. Absolute reliability and uniformity of performance of MICRO SWITCH products is assured.

### MICRO SWITCH Service

Field Engineering Service, thoroughly familiar with every type of switching problem, is readily available at branch offices in key cities everywhere.

### MICRO SWITCH Development

If an application requires an entirely new switch, MICRO SWITCH Engineering Service will cooperate with you in its development and manufacture.

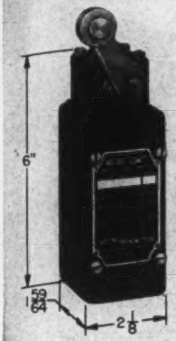
### MICRO SWITCH Savings

Precise operation, long-life dependability and freedom from maintenance of MICRO SWITCH products result in substantial savings of time and money.

# . . . have uses unlimited

HONEYWELL

## ❶ RUGGED CONSTRUCTION PLUS PRECISE SWITCHING

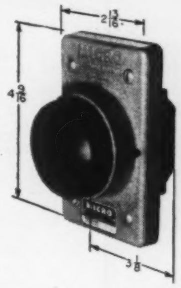


This Type "ML" heavy-duty limit switch is enclosed within a sturdy aluminum housing, which protects the precision switching unit. The housing also provides for convenient mounting and permits conduit type wiring. Both single and two-circuit switching units are available. Choice of three different actuators—adjustable roller arm, plunger and roller-plunger types.

*(Send for Catalog 83)*

## ❷ HAND SWITCH FOR POWER EQUIPMENT

This heavy-duty push button hand switch is used on punch presses and other types of hand operated power equipment. The large phenolic button operates through a sturdy aluminum cover. The switch has two double break circuits—one normally open and one normally closed. One set of contacts breaks before the other set makes.



*(Send for Catalog 83)*

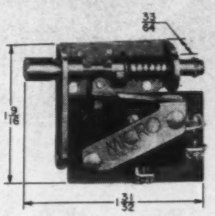
## ❸ SMALL 2-CIRCUIT LIMIT SWITCH

3 11/16
1 3/8
1 17/32

MICRO SWITCH Type "LS" is a small, sealed two-circuit limit switch for use as a control of two independent circuits. Its sealed construction, high electrical capacity and features of adjustability suit it to all types of industrial applications where space limitation is an important factor in switch selection.

*(Send for Catalog 83)*

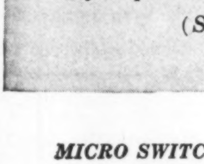
## ❹ SAFETY SWITCH DEVICE FOR HAZARDOUS EQUIPMENT



A MICRO SWITCH door interlock switch assembly for use as a safety device on hazardous equipment. The switch automatically cuts off the power when the service door is open, enabling personnel to test or repair equipment in complete safety. Assembly shown uses a MICRO SWITCH "V3" single-pole double-throw switch.

*(Send for Catalog 101)*

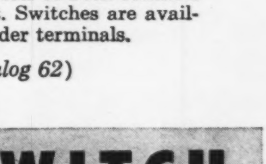
## ❺ SMALL SWITCH—BIG CAPACITY



MICRO SWITCH "V3" switches have the highest electrical capacity for their size of any switches available. They meet exacting demands of designers for an extremely small switch with no sacrifice of quality. "V3" switches are available in a wide variety of terminal designs, contact arrangements and operating characteristics. Special switch case materials may be provided to meet requirements.

*(Send for Catalog 74)*

## ❻ TWO-CIRCUIT DOUBLE-BREAK SWITCH



Keeping size and weight to a minimum, this MICRO SWITCH Type "TB" switch allows flexibility and simplicity of circuit design. A snap-action spring provides quick make and break of both contacts in each double-break circuit. Switches are available with either screw or solder terminals.

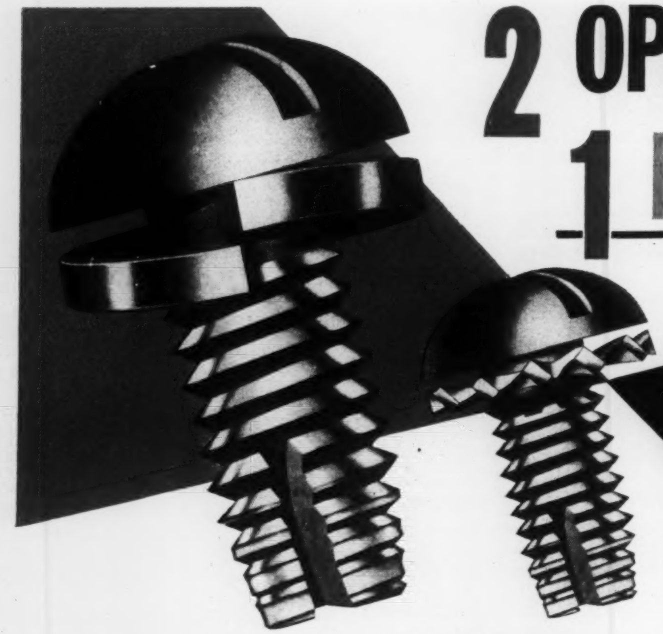
*(Send for Catalog 62)*

***MICRO SWITCH, a division of Honeywell, is a pioneer in the manufacture of precision snap-action switches***

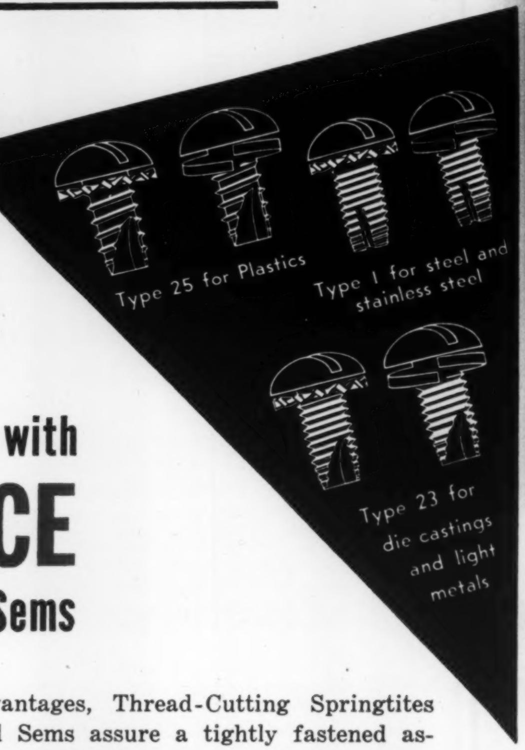
**MICRO SWITCH**

**A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY**

*In Canada, Leaside, Toronto 17, Ontario* • **FREEPORT, ILLINOIS**



# 2 OPERATIONS 1 MOTION


Type 25 for Plastics
Type 1 for steel and stainless steel
Type 23 for die castings and light metals

## Tap and Fasten Simultaneously with

# EATON-RELIANCE

## Thread-Cutting Springtites and Sems

Time expended and cost are both high in any production operation where metal must be tapped for bolt or screw type assembly. By eliminating the tapping operation, both of these factors can be reduced and resulting savings will be reflected immediately in the end cost of the product.

Eaton-Reliance Thread-Cutting Springtites and Sems have been designed specifically to give production men the advantage of accomplishing two operations with one motion. These fasteners tap and fasten at the same time.

In addition to the time and cost saving advantages, Thread-Cutting Springtites and Sems assure a tightly fastened assembly. As threads are cut, the screws are seated firmly without allowing a chance for mismating or stripping. An added plus is the preassembled Spring Washer, properly engineered to maintain constant tension. Put these fasteners to work in your assembly operation NOW.

Write for a visit from one of our fastening engineers or send for your free copy of Engineering Bulletin S-49A today.

**EATON**

**RELIANCE DIVISION**
**MANUFACTURING COMPANY**
**506 CHARLES AVENUE • MASSILLON, OHIO**

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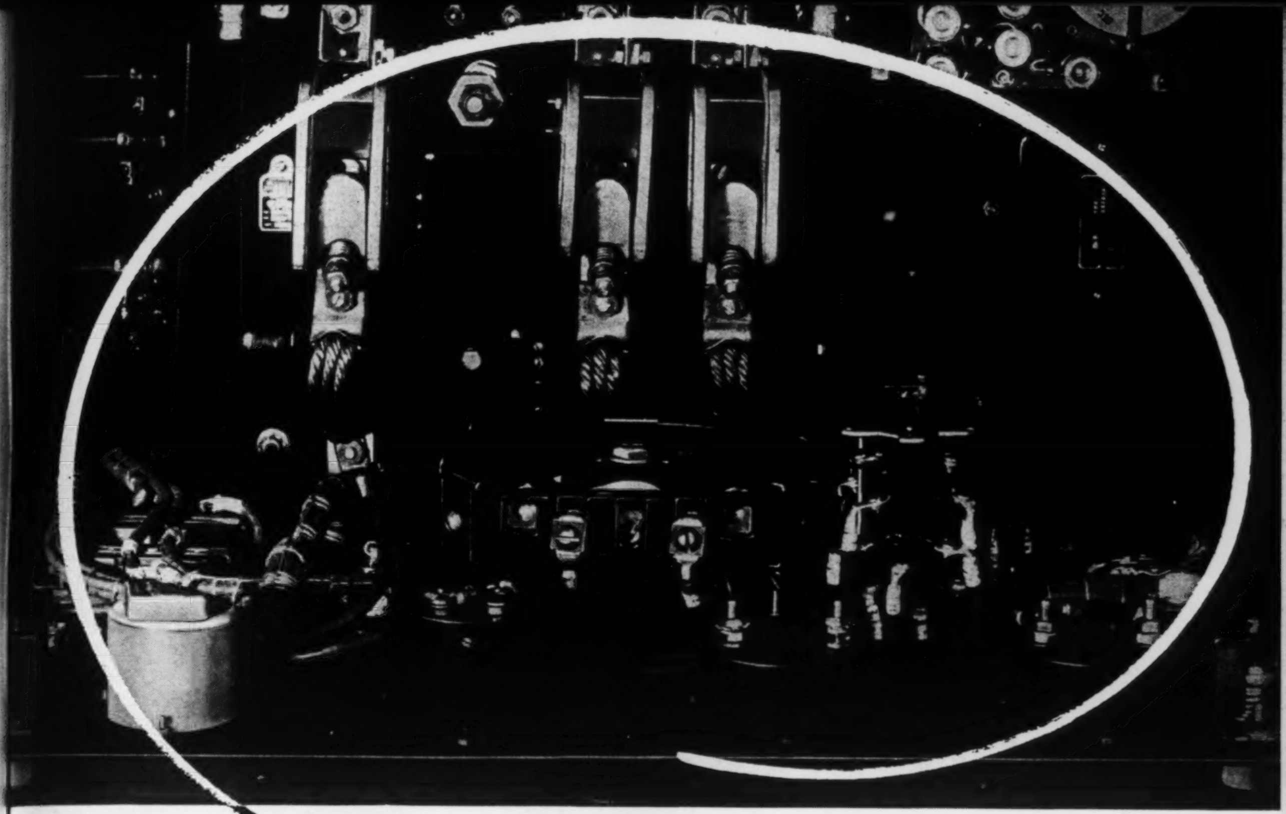
**PRODUCTS:** Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers



# ASCO Contactor meets Army specs...

## compactness, remote control & dependability

To meet the rugged tasks assigned by Army Engineers to a portable, all purpose enerator, it must be compact, versatile nd dependable. And that is why Interna-ional Fermont has specified ASCO Contactors on its new 30 KW generator.

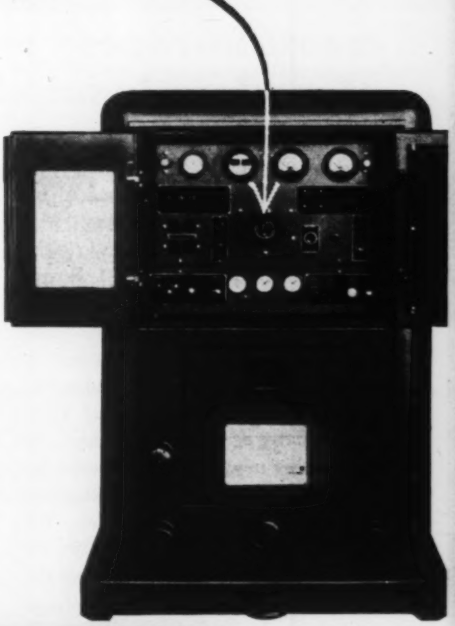
Taking up appreciably less space than is ormally required by a circuit breaker, the ASCO 3-pole A-C contactor in this instal-tion is connected between the generator nd the load. A push button located on the ront panel provides convenient remote ontrol of the contactor. The contactor it-elf is controlled by an overload relay and ust interrupt all load currents from a ault current to a short circuit.

ASCO silver alloy contact design, edge-ise wound copper blowout coils, arc hields, powerful bipolar magnet and rigid construction of all parts, insure dependable operation. These features aided International Fermont in meeting rigid Army specifications which call for:

- 208 amperes per pole contact rating
- 600 volts A-C maximum • undervoltage release at not less than 48 volts nor more than 84 volts • operating coil 120V — 60 cycles • operation in ambient temperature ranges — 65°F to 125°F.

Write for catalog data on ASCO Contactors: A-C and D-C, normally closed, normally open and double throw, also special applications for sign flashing, street lighting and heater control panels.

**Important announcement** . . . *new ASCO plant now being built in Florham Park, N. J., will double production capacity and greatly extend the range of our research, product development and services.*



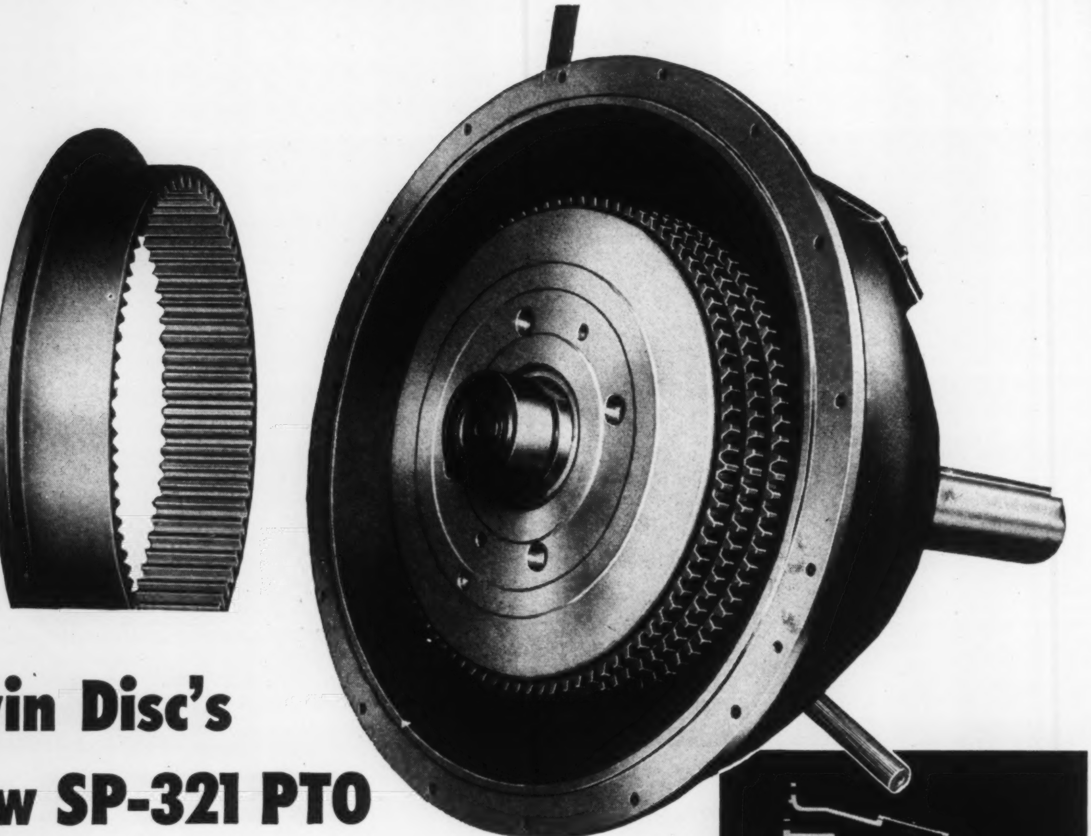
AUTOMATIC TRANSFER SWITCHES
SOLENOID VALVES • ELECTROMAGNETIC CONTROL

**Automatic Switch Co.**
**387 Lakeside Avenue, Orange, N. J. • ORange 2-5300**

ASCO

Circle 573 on page 19

XUM



# Twin Disc's new SP-321 PTO

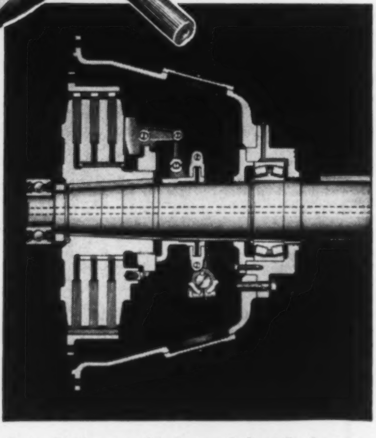
## *meets increased power requirements of modern industrial engines*

Increased rpm. . . . increased hp output—that's the trend among industrial engine manufacturers. And that's where Twin Disc comes into the picture with its new SP-321 Power Take-Off—a friction clutch designed to meet the increased power transmission requirements of today's higher speed, higher horsepower industrial engines.

Unusually compact for its high capacity, this new PTO can handle up to 6730 lbs.-ft. of torque and transmit up to 602 hp at 1550 rpm. It's available with a standard SAE No. 00 flywheel housing adapter to meet the widest range of industrial power units in its hp and rpm ratings.

Other features include a triple driving-plate construction to provide ample friction surfaces to withstand excessive heat . . . a pilot bearing with double-width bearing race for greater lubrication retention and long life . . . and a spherical roller bearing at the clutch output shaft for greater overload and side-pull capacity.

The new SP-321 Power Take-Off —along with the recently announced SP-318 and SP-314—makes the Twin Disc line of heavy-duty friction power take-offs *the broadest, most complete line available.* For full information, write Twin Disc Clutch Company, Racine, Wisconsin. Request *new* Bulletin 308.



Twin Disc's new SP Power Take-Offs feature: counter-balanced engaging linkage; positive-type clutch engagement; pilot bearing with double grease shield; clutch plates with maximum friction area; spherical roller bearing; heavy-duty, oversize output shaft; easily adjusted clutch through pin and adjusting ring.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

**TWIN DISC**
***Friction Clutches and Fluid Drives***

**TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois**

*Circle 574 on page 19*

MACHINE DESIGN
DECEMBER 13,1956

# Time for Creative Effort

WHAT engineer has not griped at the amount of time he must spend, at the expense of creative effort, just reading and writing on the job? Yet correspondence, memos and reports are here to stay, and much of their handling cannot be delegated by the engineer to an aide, however competent.

It's a curious anomaly that many engineers who may be highly conscious of machine efficiencies and production efficiencies are nevertheless quite inefficient personally. In the areas of reading and writing there is often room for vast improvement. Fortunately the means for effecting improvements are available to those willing to shake off old habits.

Take reading. The average professional or business man reads about 300 words a minute. But well-known techniques and aids to faster reading can double or treble that rate in a normal person with no loss in comprehension.

Faster "writing" offers even more spectacular savings. An educated person can write legibly 30 to 35 words per minute. But he can speak understandably four or fives times as fast. A thousand-word report (which isn't long as reports go) might require half an hour just to put the words down in longhand. Speaking the same words into a dictating machine need take only seven minutes. The extra time required to write rather than to speak adds no value to the report. And the company has to pay an engineer's salary for 23 minutes of clerical work.

How "writing" efficiency can be improved by effective use of dictating equipment is explained in Al Baxter's article beginning overleaf. To management such techniques can mean better utilization of engineering manpower. To the engineer they can mean more time for creative effort and better opportunity for advancement in his profession.

Colin Carmichael
EDITOR

By A. N. Baxter
*Mechanical Engineer, Los Angeles*

# Using Dictation Equipment

INCREASING complexity of the technical side of engineering makes communication among engineers and within departments and divisions increasingly important. Since communication is an essential, though nontechnical, aspect of engineering, it seems only logical that an attempt should be made to apply the very latest and most efficient of techniques to effect all possible time savings as well as increase accuracy in communication.

Recording and dictation equipment properly employed can produce such results. Communication by voice may be thought of as being related to pencil and paper or shorthand dictation as the modern computer is related to the slide rule.

**Advantages:** Many of the advantages of machine recording of dictation which result in time and cost savings accrue from its constant availability. A stenographer cannot be expected to be constantly present to take dictation or to record a phone conversation. The machine on the other hand can be instantly available for such tasks whether during, after or before office hours and whether in or out of the office.

More efficient use of the stenographer's time also results from machine dictation, since she does not have to sit idly while the one who is dictating thinks, looks for data, answers the phone, etc. Additionally, stenographic time is saved because her other duties need not be interrupted at inconvenient times for taking dictation, and actual transcription may often be scheduled so that other duties may be most efficiently handled.

Another advantage worth mentioning is that machine-recorded dictation can be transcribed by any stenographer while shorthand systems may be modified by individual stenographers to such an extent that the dictation is decipherable only by the stenographer who recorded it. On occasion, the stenographer who records the dictation may require help from the one who did the dictating to decipher technical terms commonly encountered in engineering.

An actual cost study, Fig. 1, shows that dictation and recording equipment can pay for itself in a relatively short time. Uses not included in the study which also produced savings were:

1. Use in shop, on field trips, etc.
2. Conference and interview recording.
3. Telephone conversation recording.

Comparisons made here have been with a stenographer using shorthand. Any study of machine dictation or recording vs. long-hand writing results in an even greater disparity in favor of the machine.

**Applications:** It must be emphasized that recording and dictation equipment are not cure-alls

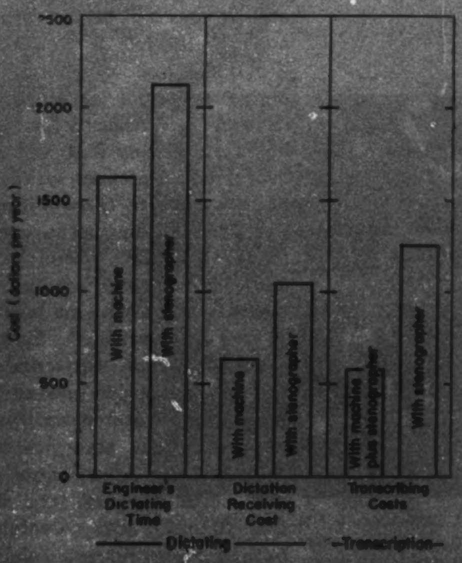


Fig. 1—Results of a cost analysis based on purchase and use of two dictation receivers and one dictation transcriber costing a total of $1200.00. Other pertinent conditions are that 1.5 hr of recording medium were used per week and equipment depreciates 50 per cent in value during the first year of use, then to zero value at the end of five years. Despite this severe depreciation, savings nearly paid for the equipment during the first year. Further analysis showed that in two years the equipment could pay for itself from savings in stenographer's wages alone; in three years from engineer's salary alone. Engineer's time cost per hour (salary plus overhead) used was $7.00.

# . . . to increase engineering output

or stenographer eliminators. The recorded voice rarely goes through the machine-stenographer combination and comes out clearer or more logical. There are certain uses, Table 1, which are *naturals* for recording or dictation. In other instances, particularly when a message is extremely short, a jotted note or dictation directly to a stenographer may be more efficient.

**Problems:** In addition to the possible problem of selling management on the purchase of recording and dictation equipment, there are two other possible trouble sources—the stenographer and the person doing the dictation. A stenographer may complain that using dictation equipment will diminish shorthand efficiency. The solution to this is to allow shorthand to be used for as many short notes and memos as may seem feasible. Two more very legitimate protests the steno can make are against spending many successive days transcribing and having to transcribe poor dictation. Solutions to these are: (1) avoid the first and (2) learn proper dictating procedure, Table 2.

Difficulties for the person dictating are largely solved by following the aforementioned rules, Table 2. However, there are two others. First is simply the initial unfamiliarity and seeming laboriousness involved in use of the equipment. A few hours of use will eliminate "mike fright" and increase output. Second problem is possible ribbing by fellow workers. This will often be shortly followed by the nuisance of having to recover borrowed equipment.

**Available Equipment:** All available recording and dictating equipment may be classified as stationary, semiportable or portable. Stationary units for purposes of this discussion are considered to be any unit exceeding 20 lb in weight. Additionally, several companies sell in-plant systems which permit dictation through a telephone. Out-of-sight wiring connects the telephone to a central-

## Table 1—Natural Applications of Dictation Equipment

1. Writing reports, memos, letters, daily logs, books and articles at office or home.
2. Recording telephone calls to increase accuracy and save time spent writing down information.
3. Accurately recording conferences, meetings and interviews with consultants, customers, potential employees, etc.
4. Communicating with superiors or assistants when out of town.
5. Abstracting information from short-loan material.
6. Receiving information when engineer is not at desk (automatic telephone answering equipment).
7. Quick compilation of tables and lists from raw data; data evaluation.
8. Verbal note taking while traveling, visiting or observing (field tests, shop inspections).
9. Compiling inventory lists.
10. Polling opinions of products.

## Table 2—Dictation Do's and Don'ts

### Before Dictation

1. Prepare a detailed outline including reminders and notes on references. Put all equations and calculations in the outline.
2. Assemble, in order, all references, charts, brochures, calculations, tables, curves, photos, oscillograph records or other material to be consulted while dictating.

### During Dictation

1. State your name, the date, subject, addressee, recipients, classification, required approvals and special instructions at the beginning of the first record.
2. Identify yourself and your subject at the beginning of each succeeding record.
3. Ask the stenographer to refer to the outline when transcribing.
4. Talk freely and rapidly; don't struggle for the best word. Keep sentences short and crisp.
5. When necessary, instruct the stenographer to leave space for correct words and temporarily unknown names or dates.
6. Continually refer to the outline.
7. Spell out people's names and difficult words. Use a phonetic alphabet.
8. Enunciate clearly and distinctly. For instance, say "cylinderrzz" for cylinders.
9. Never dictate with something foreign in your mouth such as cigarettes, pipes, pencils, gum, etc.
10. Call out all punctuation (colon, period, quote, etc.) and new paragraphs.
11. Never dictate equations!
12. Talk across, not into, the microphone.
13. Try to keep voice level and mike distance fairly constant.

XUM

# Table 3—Characteristics of

| General Information | | | | | | | | | Recording Medium Characteristics | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Manufacturer | Portability | Machine Type | Machine Cost (dollars) | Service Contract Cost (dollars/year/machine) | Machine Weight (lb) | Approximate Dimensions Width,Depth,Height (in.) | Power Requirement | Shape of Recording Medium | Initial Cost (dollars) | Recording Duration (minutes/medium) | Permanent Storage Cost | Mailability | Susceptibility to Damage During Handling | Susceptibility to Erasure During Handling | Susceptibility to Breakage During Dictation | Ease of Storage | Cross Talk, Surface Noise |
| **Magnetic Machines** | | | | | | | | | | | | | | | | | |
| 1 | SP | C | 350 | 22 | 25 | 15,15,8 | 110 v ac | Tape | 2.75 | 15 to 120 | H | PO | L | L | L | PO | N |
| 2 | SP | C | 425 | 30 | 22 | 14,16,7 | 110 v ac | Tape | 2.75 | 15 to 120 | H | PO | L | L | L | PO | N |
| 3 | SP | C | 200 | 25 | 12 | 12,10,4 | 110 v ac | Tape | 2.75 | 15 to 30 | H | PO | L | L | L | PO | N |
| 4 | P | C | 280 | N | 3 | 8, 4,2 | SCB | Tape | 11.50 | 60 | H | PO | L | L | L | PO | N |
| 5 | P | C | 300 | 25 | 3 | 7, 4,2 | SCB | Tape | 9 | 30 to 60 | H | F | L | L | L | PO | N |
| 2 | SP | C | 300 | — | 11 | 12,10,3 | 110 v ac | Tape | 2 | 15 to 60 | H | PO | L | L | L | PO | N |
| 6 | Installation $35.00<br>Rental $12.50 per mo. | | | | 30 | 15,16,6 | 110 v ac | Tape | Will handle twenty messages each 28 seconds in duration. | | | | | | | | |
| 7 | SP | DR<br>DT<br>C | 381<br>375<br>420 | 25 | 18 | 11,11,6 | 110 v ac | Belt | 0.70 | 15 | H | E | L | H | L | F | L |
| 8 | SP | C | 350 | 25 | 15 | 10, 6,9 | 110 v ac | Belt | 0.80 | 11 | H | E | L | H | L | F | L |
| 7 | SP | DR<br>DT<br>C | 365<br>380<br>460 | 23 | 28 | 12, 7,12 | 110 v ac | Wire | 20 | 15 to 60 | H | PO | L | L | H | PO | N |
| 9 | SP | C | 325 | 30 | 19 | 18,11,9 | 110 v ac | Wire | 6 | 15 to 60 | H | PO | L | L | H | PO | N |
| 10 | SP | C | 250 | 36 | 28 | 10, 6,12 | 110 v ac | Wire | 6 | 60 | H | PO | L | L | H | PO | N |
| 11 | P | C | 300 | N | 2 | 4, 7,2 | SCB<br>110 v ac<br>6-12 v dc | Wire | 6 to 33 | 15 to 300 | H | PO | L | L | H | PO | N |
| 12 | SP | C | 320 | 20 | 16 | 15,11,6 | 110 v ac | Disk | 2.50 | 10 | H | G | L | H | L | F | L |
| 13 | SP | C | 220 | 30 | 12 | 10, 9,6 | 110 v ac | Disk | 1.00 | 10 | H | E | M | H | L | F | L |
| **Embossing Machines** | | | | | | | | | | | | | | | | | |
| 5 | SP | DR<br>DT<br>C | 360<br>360<br>450 | 22 | 13 | 13,10,5 | 110 v ac | Belt | 0.04<br>0.08 | 15 or 30 | L | G | H | L | L | G | M |
| 14 | SP | C | 400 to 800 | — | 8 to 10, 4,9 | | SCB<br>110 v ac | Belt | 0.17 to 0.25 | 90 to 240 | L | E | H | L | L | G | M |
| 15 | SP | DR<br>DT<br>C | 360 | 25 | 12 | 12,10,3 | 110 v ac | Disk | 0.10 | 30 | L | G | H | L | L | G | H |
| 16 | SP | DR<br>DT<br>C | 375<br>365<br>425 | 25 | 17 | 9,12,7 | 110 v ac | Disk | 0.025<br>0.05<br>0.09 | 8<br>15<br>30 | L | G | H | L | L | G | H |
| 16 | SP | C | 275 | — | 6 | 6,10,3 | 110 v ac | Disk | — | 15 | L | G | H | L | L | G | H |
| 17 | SP | DR<br>DT | 365<br>365 | 25 | 15 | 10,10,7 | 110 v ac | Disk | 0.06<br>0.09<br>0.14 | 20<br>30<br>60 | L | G | H | L | L | G | M |
| 17 | SP | C | 425 | 25 | 15 | 10,10,7 | 110 v ac | Disk | 0.06<br>0.09<br>0.14 | 20<br>30<br>60 | L | G | H | L | L | G | M |

## Key to Manufacturers

| Code No. | Trade Name | Company Name | Address |
|---|---|---|---|
| 1 | Memo-Tape | Technical Associates Inc. | 140 W. Providencia Ave.<br>Burbank, Calif. |
| 2 | Scribe Scribbler | Permoflux Scribe | 2835 N. Kedzie Ave.,<br>Chicago 18,Ill. |
| 3 | Stenorette | DeJur-Amsco Corp. | Long Island City, N. Y. |
| 4 | Midgetape | Mohawk Business Machines Corp. | 944 Halsey St.,<br>Brooklyn 33, N. Y. |
| 5 | Dictaphone, Dictet | Dictaphone Corp. | 420 Lexington Ave.,<br>New York 17, N. Y. |
| 6 | Pacific Telephone | Bell Telephone System | |
| 7 | Pierce | Pierce Dictation Systems Corp. | 5900 Northwest Highway,<br>Chicago 31, Ill. |
| 8 | Comptometer | Felt and Tarrant Mfg. Co. | 1735 N. Paulina,<br>Chicago 22, Ill. |
| 9 | Steno | Crescent Industries Inc. | 5900 Touhy Ave.,<br>Chicago 31, Ill. |
| 10 | Dictascriber | The Magnetic Corp. of America | Chicago 22, Ill. |
| 11 | Minifon | Geiss-America | Chicago 45, Ill. |

# Available Dictation Equipment

| Dictation Characteristics | | | | | | | | | | | | Transcription Characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adequacy of Microphone Controls | Play Back Fidelity | Physical Shock Sensitivity | Susceptibility to Accidentally Not Dictating | Recording Level Indicator | In Recording Position Indicator | End of Dictation Indicator | Ease of Record Review | Indexing System | Performance as Conference Recorder | Speed of Total Erasure | Telephone Attachment | Ease of Starting and Stopping | Ease of Locating Errors | Ease of Back Spacing | Ease of Refinding Position on Medium | Earpiece Quality | Speed Control | Tone Control | Volume Control |
| E | E | L | L | N | E | N | F | E | E | H | Y | G | E | G | E | F | N | Y | Y |
| E | E | L | M | N | G | N | F | PO | E | H | Y | G | PO | G | PO | G | N | Y | Y |
| F | G | L | M | N | G | N | PO | F | G | H | Y | F | PO | E | PO | E | N | Y | Y |
| N | PO | L | M | N | N | N | PO | PO | F | L | Y | PO | PO | PO | PO | F | N | N | Y |
| N | F | L | M | N | PO | N | PO | PO | PO | L | N | PO | PO | G | PO | F | N | N | Y |
| — | — | L | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| — | G | L | | This is automatic telephone answering unit. | | | | | | | | Units available from which transcriptions can be made. | | | | | | | |
| G | G | L | M | N | PO | Y | G | G | G | H | Y | G | G | E | G | G | Y | Y | Y |
| G | G | M | M | N | F | Y | G | F | G | H | Y | G | F | G | F | G | N | Y | Y |
| F | G | L | M | N | N | N | F | E | G | H | Y | G | PO | F | PO | F | N | N | Y |
| PO | G | L | H | Y | N | N | PO | G | G | H | Y | G | G | E | G | G | N | N | Y |
| PO | G | L | H | Y | N | Y | F | G | G | H | Y | G | G | G | G | G | N | Y | Y |
| N | F | L | M | N | PO | Y | F | PO | F | H | Y | F | PO | F | PO | G | N | N | Y |
| P | G | H | M | N | PO | Y | F | PO | PO | H | Y | F | F | F | F | F | N | N | Y |
| F | G | M | M | N | N | N | G | F | F | H | Y | G | F | PO | PO | F | N | N | Y |
| G | G | M | L | Y | Y | Y | G | G | G | N | Y | G | G | G | G | G | Y | Y | Y |
| F | F | M | M | Y | N | Y | G | F | G | N | Y | F | F | F | F | F | Y | Y | Y |
| F | PO | K | H | N | PO | Y | F | F | PO | N | Y | G | PO | G | PO | F | Y | Y | Y |
| G | F | M | L | Y | Y | Y | G | G | F | N | Y | G | E | G | G | F | Y | Y | Y |
| F | F | H | H | N | PO | Y | G | F | F | N | N | F | F | N | F | F | N | N | Y |
| G | F | M | M | Y | Y | Y | G | G | F | N | Y | G | F | G | PO | F | Y | Y | Y |
| G | F | M | M | Y | Y | Y | G | G | F | N | Y | G | F | G | PO | F | N | Y | Y |

## Key to Manufacturers

| Code No. | Trade Name | Company Name | Address |
|---|---|---|---|
| 12 | Rex | American Dictating Co. | 65 Madison Ave.,<br>New York 16, N. Y. |
| 13 | Voice-Master | Magnetic Recording Industries | 30 Broad St.,<br>New York 4, N. Y. |
| 14 | Walkie Recordall | Miles Reproducer Co. Inc. | 812 Broadway,<br>New York 3, N. Y. |
| 15 | Tele-Voicewriter<br>Ediphone<br>Vice President | Thomas A. Edison Inc. | West Orange, N. J. |
| 16 | Sound Scriber | The SoundScriber Corp. | 145 Munson,<br>New Haven, Conn. |
| 17 | Audograph | Gray Mfg. Co. | 16 Arbor St.,<br>Hartford 1, Conn. |

## Key To Code Letters

*C* = Combination Unit
*DR* = Dictation Receiver
*DT* = Dictation Transcriber
*E* = Excellent
*F* = Fair
*G* = Good
*H* = High
*L* = Low
*M* = Medium
*N* = No or None
*P* = Portable
*PO* = Poor
*S* = Stationary
*SP* = Semiportable
*SCB* = Self-Contained Batteries
*Y* = Yes

ly located group of recorders. Lights on the phone show which machine is available for use, and pushbuttons permit selection. An attendant at the receiving end changes the recording medium when it is filled.

Advantages of such a system are concealment of the recorders and corresponding low space requirements on the desk top of the person dictating. Disadvantages, in addition to the lack of portability, are: (1) the possibility of all recorders being in use when it is desired to dictate, (2) high cost for a small installation, (3) need for an operator at receiving end, (4) difficulty in making log or index cards, and (5) difficulty in reviewing, or playback, without special equipment.

Semiportable units are those weighing from 12 to 20 lb and occupying sufficient volume to make them inconvenient for travelling. Only real disadvantage of these units is their lack of portability. However, they can be easily moved on a typewriter table or within a building. Fidelity is usually good and these units are quite versatile.

Portable units weigh approximately 2 lb. Any weighing more than 4 lb create definite travel inconvenience. Some of these units are small enough to be carried in a coat pocket, while others are provided with camera-type carrying cases. Although these units are usually designed for operation using self-contained batteries as a power source, some may also be operable on 110 v ac or dc and from a 6 or 12 v dc source as in an automobile by using a converter to change the dc to ac. Recording media are usually difficult to mail. As compared to other types, only advantage of portable units is their portability.

Another way in which recording or dictating equipment may be classified is by function. That is, as (1) dictation receivers, (2) dictation transcribers or (3) combination units which will both receive dictation and permit transcribing. Dictation receivers do, of course, permit playback or review of what has been recorded. However, earphones or foot-actuated switch to permit convenient transcription cannot be attached to the dictation receiver.

Dictation transcribers do not permit recording. They operate with the recorded medium from a dictation receiver or a combination unit. Either hand or foot controls for speed, reversing and rapid backup are usually incorporated. Earphones may be, or are, attached to the transcriber.

Combination units offer all the features of recorder and transcriber. Of course, both operations cannot be performed simultaneously. Although cost is usually somewhat higher than single-purpose equipment, the increased versatility at a cost less than that of two single-purpose units may be well worth it. Of course, there is the possibility that the unit may be in use for transcription when it is desired to dictate or vice versa.

Other differences to be considered in dictation equipment selection are the recording system and the various recording mediums used. The two basic methods used in recording are embossing and magnetization. Embossed media may be disks, belts or cylinders. Magnetic media include wire, disks, tapes or belts.

There are certain inherent advantages and disadvantages associated with these recording systems and the recording media. Embossed cylinders, for example can be completely destroyed by rough handling and ensuing breakage. Other disadvantages of the embossing system regardless of shape of the medium include:

1. Erasure and correction during dictation not possible.
2. Fidelity losses as embossing styli wear.
3. Possibility of record surface noise, cross talk and echos.
4. Susceptibility to mechanical shock causing stylus jump.
5. Cost of stylus replacement.
6. Susceptibility to groove damage by dust as well as handling while in use and in storage.
7. Low sensitivity for conference recording.
8. Relatively short dictation interval.

There are, of course, certain advantages of the embossing system. These include:

1. Ease of mailing recording medium.
2. Low cost of permanently retained recordings.
3. Reasonably rapid location of specific bits of dictation on the medium.

It should be noted in regard to the second advan- listed that once material is transcribed, procedures and cost of permanent retention of the transcribed material are identical regardless of the recording method.

Outstanding advantages of magnetic recording are the fidelity or clarity of reproduction and instant erasibility. Typists need not anticipate or search for errors nor must they strain to hear and understand. The ability to erase and correct is also a great psychological aid to the one dictating.

Magnetic recorders are generally quite resistant to mechanical shock, an important requisite for a portable machine. Additionally, tape and wire recorders are the only types which can be made sufficiently small and light to be truly portable. Another general advantage of magnetic recorders is their sensitivity. This makes them particularly useful for such things as recording proceedings of a conference. At times this may be a disadvantage because background noises may be picked up along with dictation.

First cost of magnetic recording media is high as compared to cost of embossed media. However they may all be erased magnetically and used over and over again.

First magnetic recording medium to be developed was stainless-steel wire. Since the wire is only a few thousandths of an inch in diameter it tends to break when subjected to shock loads and temperature extremes. Although it is sometimes possible to knot the broken ends and proceed, the knot is a point of stress concentration and is apt to cause another break to occur. Although wire reels are more difficult to mail than tape reels, belts or disks, they offer more recording time per unit volume than these other media.

Magnetic tape probably incorporates more advantages than other magnetic recording media. It is not easily damaged nor accidentally erased during handling or mailing. Dictation time may be several hours. Machines for use with magnetic tape have achieved a very high degree of development. Some of the more interesting features are: (1) speedometer type position indicator which when used with a log allows quick, easy location of a particular section, and (2) foot-operated microphone switches which leave both hands free for talking.

Magnetic belts do not offer the duration of recording time available with wire or tape. Maximum recording time is from 10 to 15 minutes. Handling and storage is more convenient than for wire or tape since the belts may be folded.

Magnetic disks are durable, reusable and easily mailed. Recording time is limited to about 15 minutes. Disadvantages of disks and associated equipment are poor portability and mechanical shock sensitivity.

**Selection:** To select the proper dictation equipment it is necessary to consider the requirements of a particular application carefully and match them as closely as possible with the features of available equipment. Cost is also an important consideration—not only first cost but continuing costs such as for purchase of recording media. Many of these characteristics are summarized in Table 3 for the majority of available equipment.

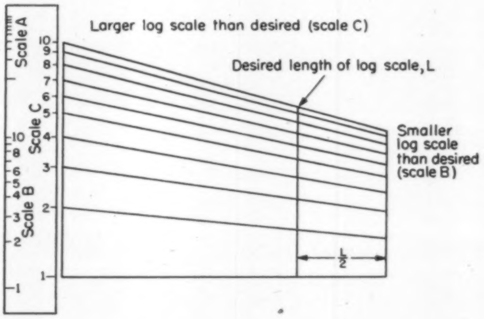
There is one more extremely important factor which probably cannot be too strongly emphasized. No matter how well requirements and characteristics are matched on paper, the equipment will not be satisfactory unless it is physically convenient to operate from the standpoint of both the individual dictating and the person transcribing. This evaluation can only be made by using the equipment. In most instances equipment can be borrowed for a trial period or perhaps rented. When equipment is rented, it may be possible to apply the rental to the purchase price if purchase is decided upon.

# Tips and Techniques

## Log Ruler

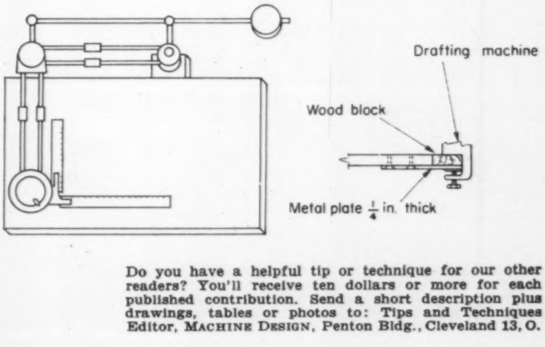
A special log ruler like that shown may be easily constructed and can be extremely useful in constructing special nomographic scales. To construct the rule, different decade lengths are cut from log paper and cemented to a strip of plastic or acetate. Scales may be any convenient length but lengths of 2, 4 and 6 in. have been found to be extremely useful.

To use the scale to construct a log scale of any length, $L$, the proper length, $L$, is first measured. Then scale $B$ is drawn any convenient distance from $L$. In many cases, a distance $L/2$ will prove to be quite convenient. Guide lines are then drawn from the ends of scale $B$ through the ends of $L$ and extended until they converge or diverge sufficiently to fit scale $A$ or $C$. Scale $A$ or $C$ is then drawn and corresponding graduations are then joined with those on scale $B$ to produce the required intersections on $L$.—Kenneth G. Leib, *Sylvania Electric Products Inc., Kew Gardens, N. Y.*


Scale A
Larger log scale than desired (scale C)
Desired length of log scale, L
Scale C
10
9
8
7
6
5
4
3
2
1
Scale B
10
8
6
5
4
3
2
1
Smaller log scale than desired (scale B)
$\frac{L}{2}$

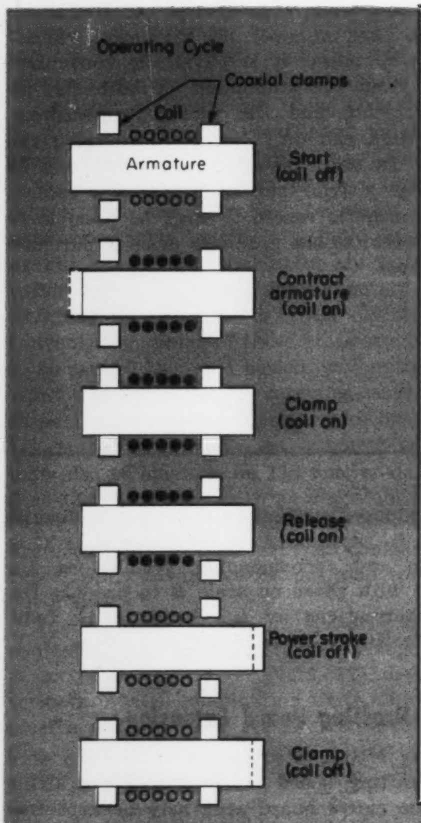
## Drafting Board Extension

By adding a simple extension to the top of a standard drafting board for mounting a drafting machine, the entire board area may be kept free from the drawing. Details of such an extension are shown. Width of the block should be to suit the drafting machine. Thickness of the block should be equal to that of the drawing board.—William R. Barlow, *Muncy, Pa.*



**Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, Machine Design, Penton Bldg., Cleveland 13, O.**

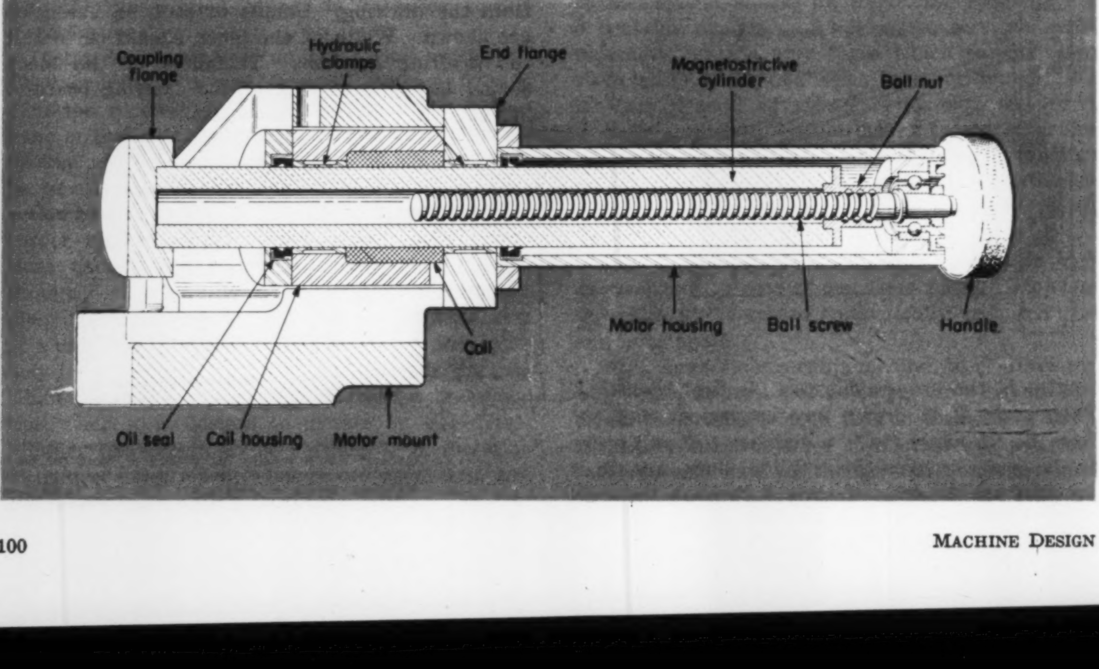
# scanning the field for Ideas

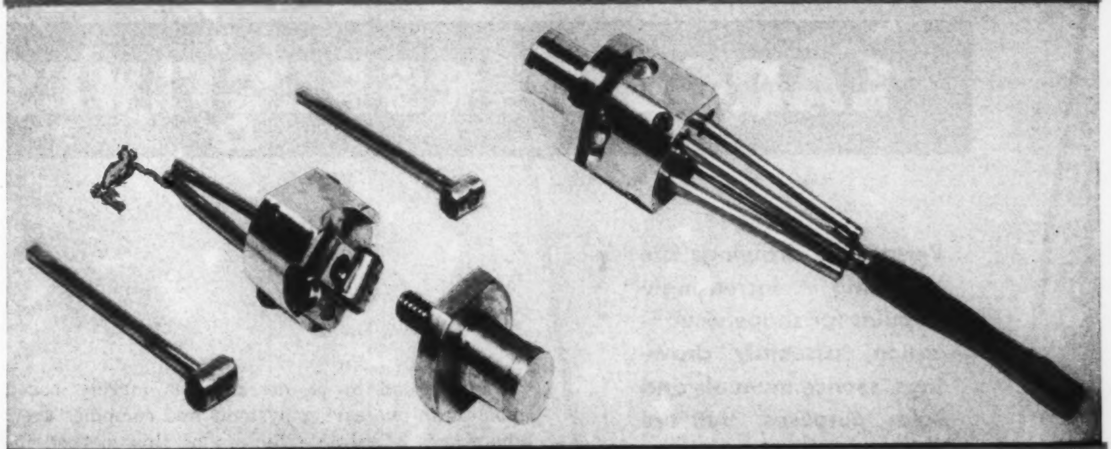

Operating Cycle
Coaxial clamps
Coil
Armature
Start (coil off)
Contract armature (coil on)
Clamp (coil on)
Release (coil on)
Power stroke (coil off)
Clamp (coil off)

**PRECISION POSITIONING** of machine assemblies is accomplished without backlash in a novel electrical linear-actuator design. Developed by E. Silver and G. S. Butterworth of Airborne Instruments Lab. Inc., the actuator motor, which is tradenamed Inchworm, produces an incremental, linear stepped motion by the magnetostrictive effect.

In operation, the armature of the motor shrinks under the influence of an electromagnetic field developed by the coil. If the coil is de-energized, the armature snaps back to its original size. Direction of linear motion of the coil housing in relation to the armature is controlled by the proper sequencing of the locking action of a pair of coaxial clamps in the housing ends. Size of stepped movements in either direction depends on load, spacing of the two clamps, and amount of current in the coil.

The clamps are fluid-filled cylindrical grooves covered with a membrane that contacts the armature. When lock-up of a given clamp is desired, hydraulic fluid is applied in the groove under pressure to deform the membrane and form a friction lock with the armature.


Coupling flange
Hydraulic clamps
End flange
Magnetostrictive cylinder
Ball nut
Motor housing
Ball screw
Handle
Coil
Oil seal
Coil housing
Motor mount

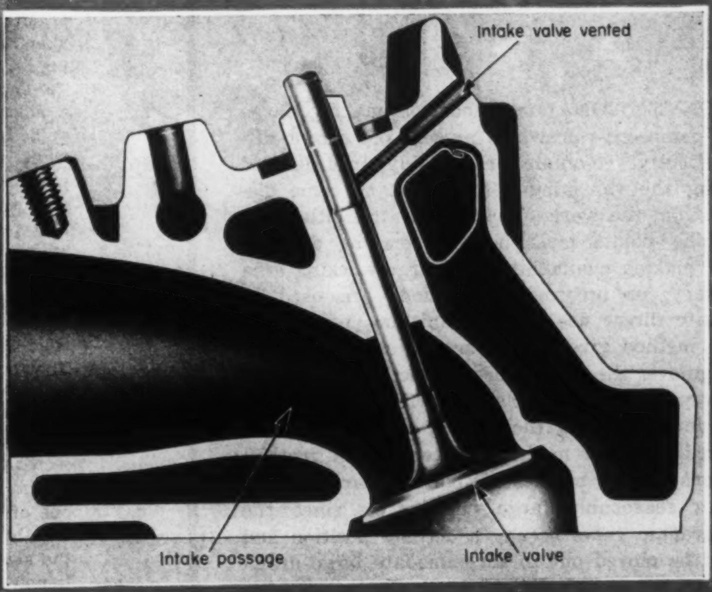


**CLAMPING OF IRREGULAR SHAPES** under high-temperature conditions is accomplished by a novel sample-holder construction. The design was developed by Julius Soled, Signal Corps Engineering Lab., Fort Monmouth, for holding silicon rods in an induction heater.

Set screws press against each of four tungsten fingers to lock an object in place. Radial movement of each tungsten finger is permitted by a T-bar pivot construction.

The assembly is easy to clean and the metal-to-metal contact of the components improves cooling of the clamping fingers.

**VENTED VALVE CONSTRUCTION** for internal combustion engines simplifies lubrication problems in vacuum environments. In 1957 Pontiac V-8 engines, atmosphere is admitted to a space between the intake valve stem and stem guide through a drilled hole in the cylinder head. Vacuum developed within the intake passage during engine operation is thus prevented from drawing lubricating oil into the combustion chamber through the clearance between the valve stem and its guide.



XUM

# LARGE PERSPECTIVES

**Perspective drawings are becoming increasingly popular for shape visualization, assembly drawings, service manuals and sales purposes, but are difficult and time consuming to make. This article presents a rapid and simplified method for large perspectives, utilizing a mastersheet underlay which may be reused.**

By Victor Paquet, Glenn Dewey
and George Charron
*Division of Graphics*
*University of Vermont*
*Burlington, Vt.*

CONVENTIONAL methods of making large perspective drawings present one major difficulty. To obtain a reasonably large finished drawing the vanishing points must be some distance from the work. This means that either the vanishing points must be kept on the drawing board, making availability of a large working area necessary, or involved calculations are used to eliminate direct use of the vanishing points.

The method given here has one substantial advantage over the method-of-intersections approach[1] to perspective projections. The final drawing is large in relation to the size of the construction required. In the method-of-intersections method the construction must be impossibly large to get even a reasonably large perspective, since the orthographic views occupy a definite position and cannot be moved out to accommodate large drawings. An ingenious solution, which eliminates using inaccessible points by means of scales, has been published,[2] but the scales are difficult to construct.

The method to be described is largely based upon these two earlier systems and combines their advantages. Desirable factors of this method include: need for special equipment is eliminated, work may be done on a medium-size drawing board, and very little background theory need be referred to. The computations for making the master chart are simple and fast. Very little preparatory work is necessary; only a three-view orthographic drawing on tracing paper and the master chart are required. The master chart has fixed view angles

## *Making the Drawing*

Constructing a perspective drawing by use of the master chart is simple and fast.

1. Three views of the object are drawn on tracing paper, cut out, and taped to the master chart in their revolved, correctly oriented positions as shown.
2. Tracing paper to be used for the drawing is taped over the master chart.
3. To locate any point in the perspective, a sharp pencil is placed on the desired point in any one of the three views. The right side will be used for illustrative purposes. A straightedge is then aligned with the selected point and point *D'*.
4. The pencil is then moved to the point where the straightedge intersects scale 5.
5. The straightedge is pivoted about the pencil to align with point 1.
6. Pencil is moved to where the straightedge intersects scale 6.
7. The straightedge is pivoted about the pencil until it passes through like readings on scales 5 and 6.
8. This places the straightedge on a projector carrying the given point.
9. A similar procedure is carried out using one of the other views, and the intersection of the two projectors is a point on the perspective. As one becomes accustomed to the process, the steps become automatic and the pictorial builds up rapidly.

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[1] References are tabulated at end of article.

# SIMPLIFIED

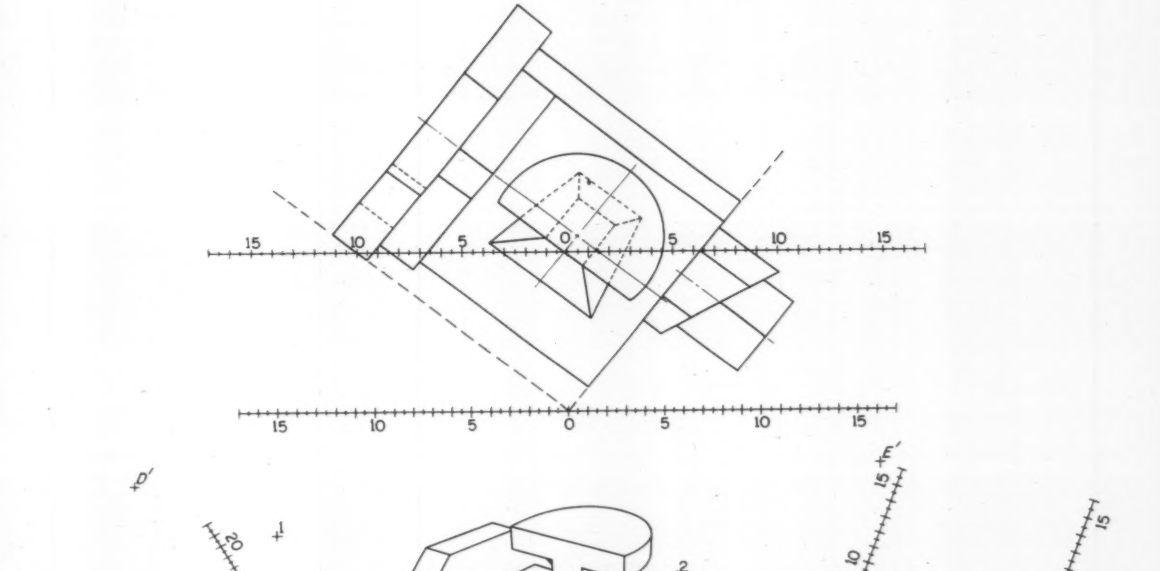

15
10
5
0
5
10
15
15
10
5
0
5
10
15
D′
1
2
E′
20
15
10
5
0
5
10
15
20
Scale 5
Scale 6
3
F′

Fig. 1

# Constructing the Master Sheet

1. Establish axes $x$, $y$, $z$, Fig. 2.1.
2. Locate the picture plane traces, $AB$, $BC$, $AC$, with lines perpendicular to their respective axes.
3. Revolve the reference planes, Fig. 2.2. Using trace $AB$ as an example, bisect the trace, and using radius of $AB/2$, locate point $F$ on $y$ axis. Join points $AF$ and $BF$.
4. Locate measuring point. Draw a line perpendicular to axis $y$ from point $O$ to trace $BC$ (or $AC$), Fig. 2.2, then parallel to axis $y$ to

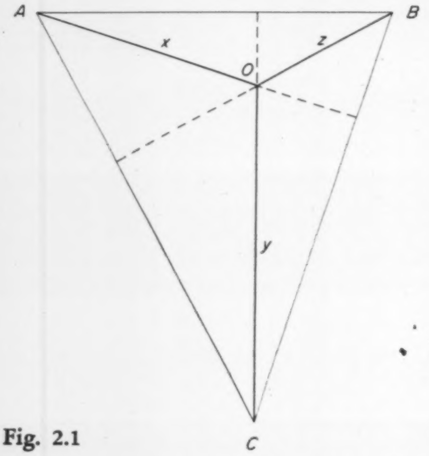


Fig. 2.1

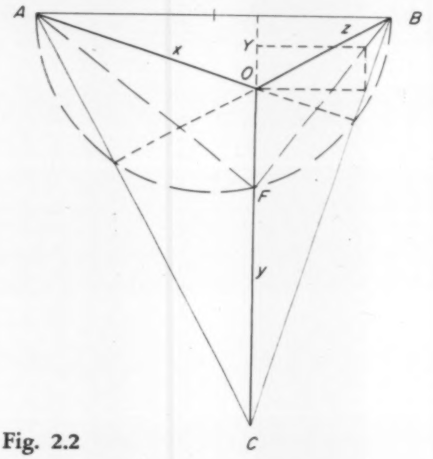
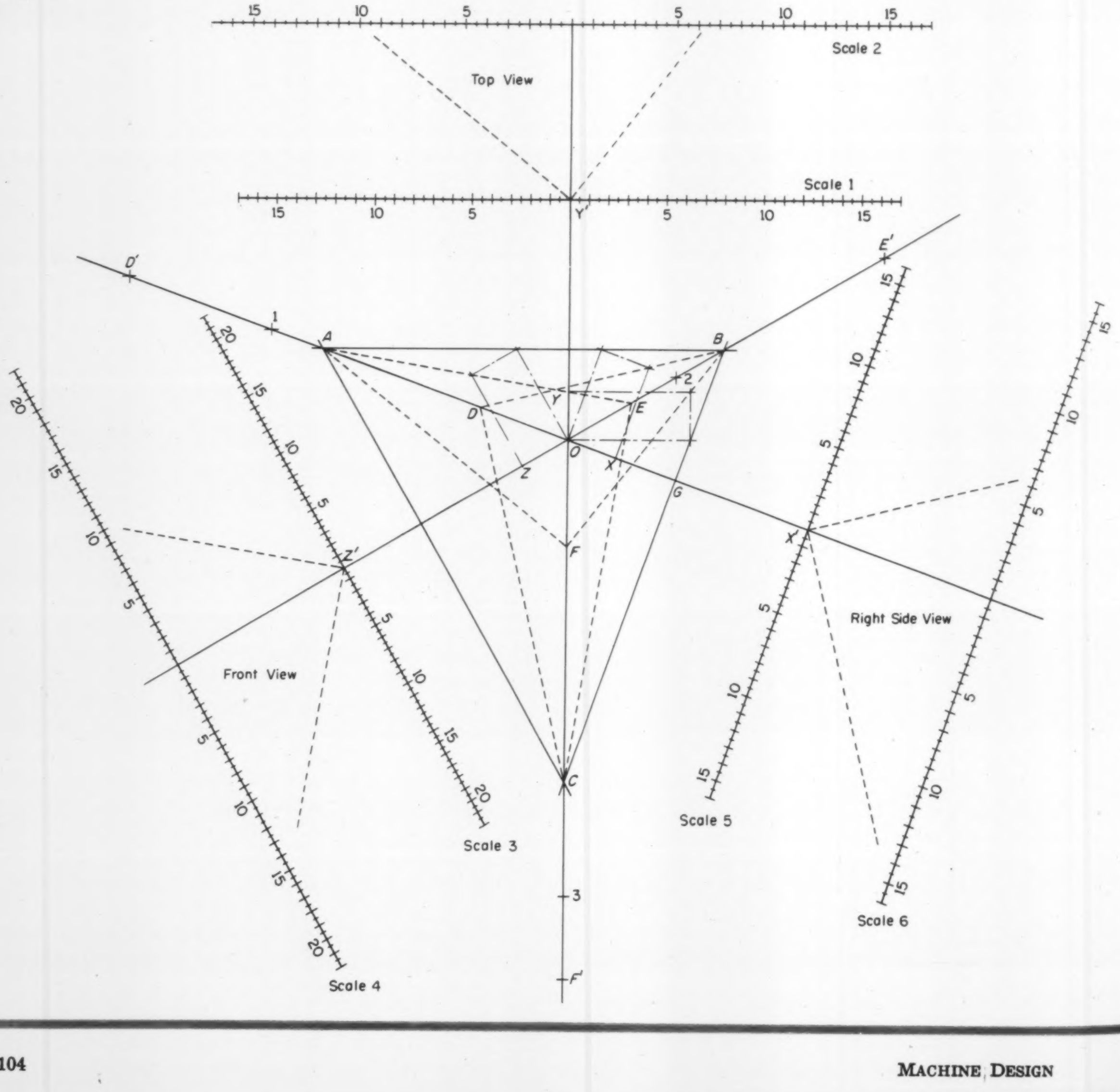


Fig. 2.2

Fig. 2.3


15
10
5
5
10
15
Scale 2
Top View
Scale 1
15
10
5
Y'
5
10
15
D'
E'
1
A
B
2
D
Y
E
O
X
Z
G
F
Z'
X'
Front View
Right Side View
C
Scale 3
Scale 4
Scale 5
Scale 6
3
F'

but does not limit the physical size of the subjects which may be drawn. Inasmuch as the master chart may be used repeatedly, two or three such charts drawn to different view angles are normally sufficient for all work which is to be done.

Use of the master chart is illustrated in Fig. 1, and its construction is given in Figs. 2.1 through 2.6. Calculations required are given in illustrations.

There is little doubt that projecting directly from orthographic views has a number of advantages over other methods. Points on circles or irregular curves become points to be handled like all others without becoming involved in some scheme of transferring co-ordinate measurements. Visualization of the pictorial as it builds up is considerably easier with the orthographic views to work from. Additional vanishing points for angular planes are unnecessary. Measuring lines are eliminated since the size of the finished drawing is based upon the size of the orthographic views.

Scales on the chart are used to align a straightedge with inaccessible points. Two steps are required, as explained in Fig. 1, one to locate the pivot point on the side of the enlarged true triangle and the other to head the straightedge for the corner of the enlarged triangle. Many ideas for placing the scales and pivot points were tried out before the present scheme was reached. Undoubtedly more improvements and refinements are possible, but the method as it stands is complete. The practical aspect of this method as a way of making perspectives is proved by Fig. 1, which would certainly be more difficult by other methods.

REFERENCES

1. S. B. Elrod—"Simplified Pictorial Drawing," MACHINE DESIGN, Vol. 25, No. 3, March, 1953, Page 128.
2. F. W. Reighard—"Perspective Drawings," MACHINE DESIGN, Vol. 27, No. 11, November, 1955, Page 148.

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edge of rotated reference plane (line $BF$ or $AF$), and then perpendicular to axis $y$ and back to it. This locates point $Y$. $YO$ is for measurement purposes and is the basis for constructing the scales on Fig. 2.3. Repeat steps 3 and 4 for other two axes to locate points $X$ and $Z$.

5. Enlarge finished drawing, Fig. 2.2, by some desired factor, locating points $A'$, $B'$, $C'$, as far away as possible (usually off the board) without letting points $D'$, $E'$, $F'$, become inaccessible. Points $D'$, $E'$, $F'$ represent points $D$, $E$, $F$ moved to their "enlarged" positions. A factor of five was used in the chart in Fig. 2.3, i.e., distance $OF'$ is 5 times distance $OF$ and other dimensions are similarly enlarged. In the calculations a considerable amount of time may be saved by scaling the necessary dimensions and multiplying by the enlargement factor or by stepping off with dividers. The dimensions 36 (5 times $AX$), 16.71 (5 times $DX$), 23.91, and 43.20 are thus located on line $A'G'$, Fig. 2.4. If the original drawing is carefully made these points are sufficiently accurate.

Fig. 2.4

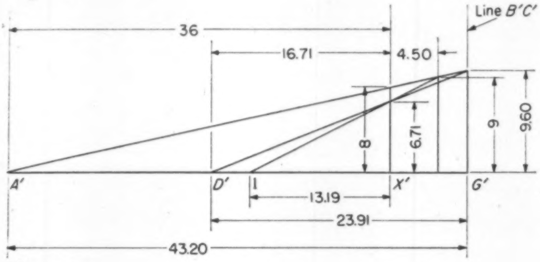


Fig. 2.5

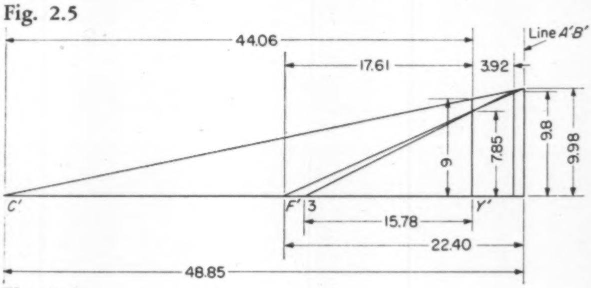
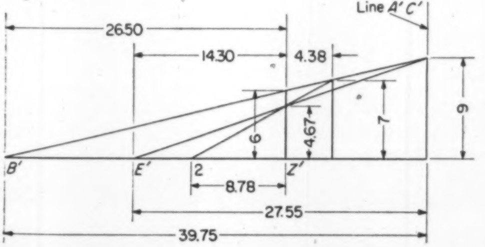
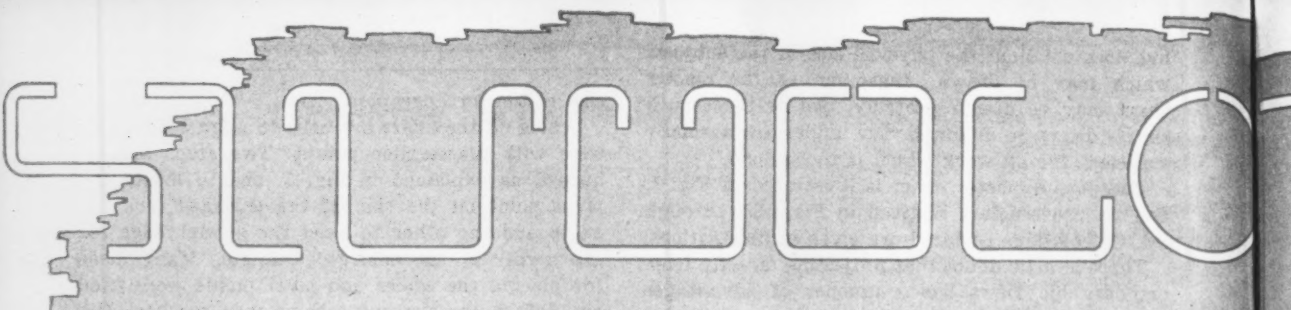


Fig. 2.6



6. Locate the scales and scale moduli. The calculations will be explained using the right side view and Fig. 2.4 as an example. The scale at $X'$ is used both as a graduated scale and a pivot line. The other graduated scale is to be placed out from point $X'$ and must be, due to space limitations, about 5 in. away. Consequently the proportion $36:36 + 5$ is set on the slide rule to determine what convenient numbers come close to this ratio. The numbers 8 and 9 are decided on and become the scale moduli. This changes the distance between scales from 5 in. to 4.5 in., and establishes their vertical length in the triangle, Fig. 2.4.
7. Calculate the scale moduli. It is necessary to find the modulus of a scale on line $B'C'$ which will align with scale $X'$ and its modulus of 8, and $A'$. By similar triangles the proportion, $36/43.20 = 8/\text{unknown}$, is obtained, yielding a scale modulus of 9.60. Next it is desired to find the modulus of the pivoting scale which coincides with scale $X'$ in position. The proportion, $9.60/\text{unknown} = 23.91/16.71$, is obtained, giving a value of 6.71 as the scale modulus.
8. Find point 1. The above information is sufficient to locate point 1 by similar triangles. The proportion (distance $X'$ to point $1)/6.71 = 4.50/(9 - 6.71)$ gives 13.19.
9. Graduate the scales. Choose some convenient scale and scale 8 units on scale $X'$ and 9 units on scale 6, Fig. 2.3. They may, of course, be subdivided as many times as desired. The eye is quite critical in estimating proportion and a minimum of marking is sufficient.

The process is repeated for the top and left views, Figs. 2.5 and 2.6. When this is finished, the master chart is ready for use.



# *Production Design Techniques for* Cold Roll Forming

COLD roll forming is the process of continuous shaping, without heat, ductile sheet or strip metal with a series of progressive forming rolls. Because of high production capacity, uniformity of cross section or profile throughout part length, and closely-held dimensional tolerances, roll forming is extensively used.

The automotive industry, for instance, relies on roll forming for millions of feet of trim, scuff plates, and rims. Aircraft designers specify roll-formed structural members such as hats, channels, zees, tees, and others.

In many cases, accelerated production rates and the added strength gained from cold working have caused replacement of extrusions by roll-formed sections. Cold roll forming permits conversion of materials with high strength properties into desired design configurations, Fig. 1.

Action of the rolls against the metal tends to improve the natural finish, besides adding strength. For this reason, roll-formed metal shapes in the building industry have become roofing, siding, joists, window and door trim, screen frames, conduit, gutter and downspouts, lighting fixtures, and ridge rolls. Farm buildings, garages and hangars utilize corrugated roofing and V-crimp sheets.

Roll-formed lock-seam and butt-seam tubing are universally popular as electrical conduit, alpeth cable and television antennas. Trailer manufacturers have adopted special structural sections for their monocoque or stressed-skin structures and sharply corrugated floor partitions.

## Planning for Cold Roll Forming

Emphasis must be placed on the high production capacity of cold roll forming when selecting

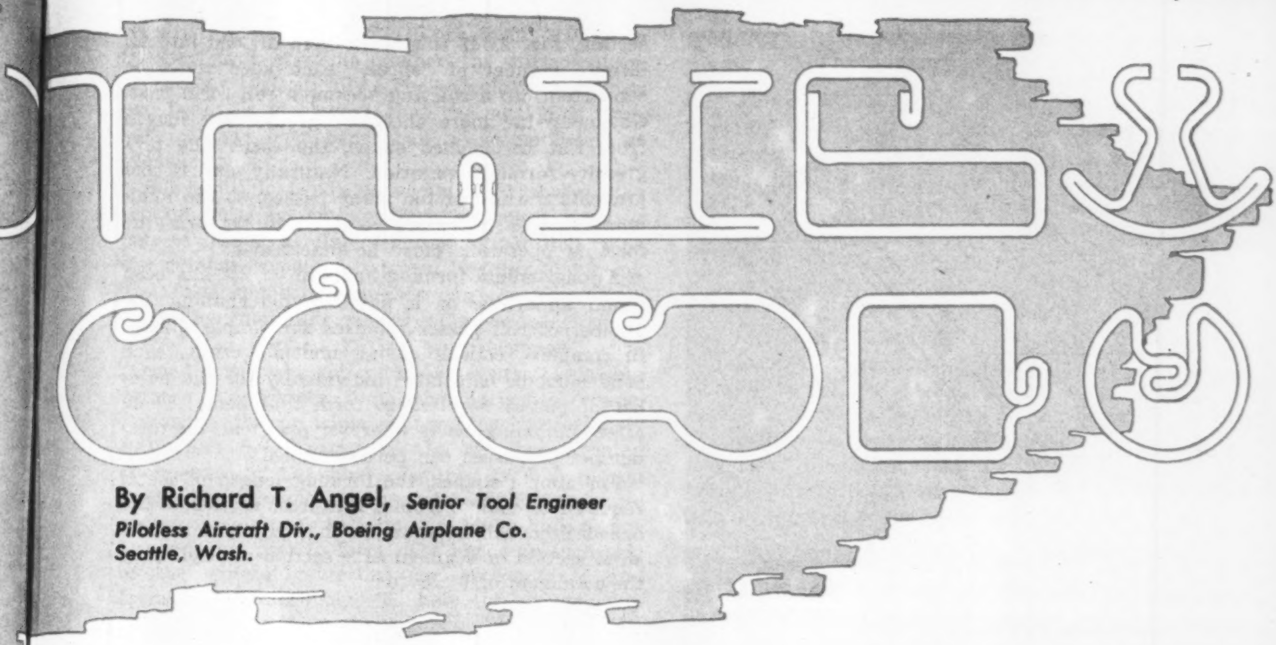
- **Factors a designer must consider in specifying cold roll forming as a method for production of parts**
- **Advantages and limitations of the process**
- **Planning the part for easy production**
- **Auxiliary forming and production operations**
- **Tolerances**
- **New metals**

**Table 1—Cold Roll Forming Machines**

Many sizes of machines, having various shaft diameters and horizontal distances between shaft centers, are available. Dimensions governing roll design and the mild steel capacity of a few of the machines commonly employed for cold roll forming are:

| Shaft Diam (in.) | Horizontal Distance Between Shafts (in.) | Mild Steel Capacity: Area of Section (sq in.) |
|---|---|---|
| 1½ | 11 | 0.5 |
| 2 | 15 | 1.125 |
| 2½ | 18 | 1.750 |
| 3 | 24 | 2.500 |

Such machines are available commercially with up to 20 sets of shafts; however, 10 shafts are most common. Capacities given depend on shape of the section to be formed. Sections of the same height will require anywhere from 4 to 20 passes, depending on the shape.



**By Richard T. Angel,** *Senior Tool Engineer*
*Pilotless Aircraft Div., Boeing Airplane Co.*
*Seattle, Wash.*

this process as a method of fabrication. Roll forming machines, Table 1, operate at speeds ranging up to 200 fpm which, when translated to actual footage produced, amounts to 3000 to 5000 ft per working hour. Without considering amortization of the roll forming machine, the engineer may be guided generally by the following factors when weighing roll forming as a means of fabrication:

1. At least 50,000 ft annually to amortize tooling. This footage may be a total of several standard sections to be formed on the same rolls. Consideration must be given to the number of setups required to attain the total footage.
2. Consistent uniformity of section throughout part length is desired.
3. Minimum sectional tolerances and tight radii are required.
4. Section can be cut to part length as a combined operation.
5. Section may be pierced, notched, coiled, stencilled or embossed as part of the roll form operation.

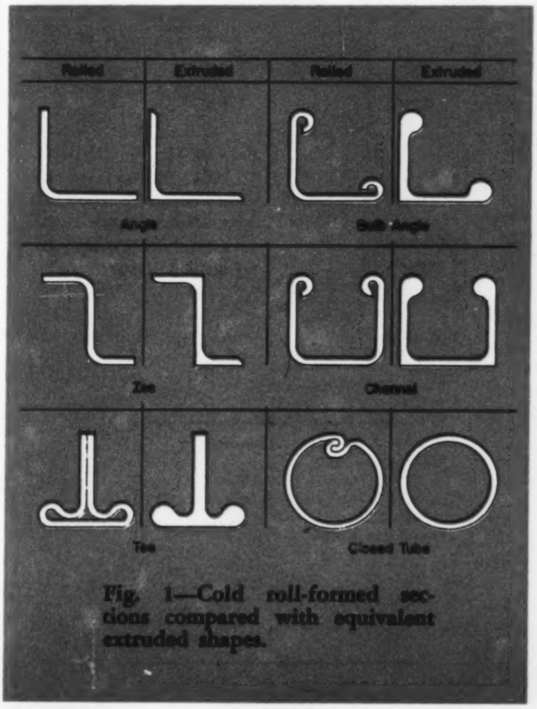


Fig. 1—Cold roll-formed sections compared with equivalent extruded shapes.

These factors all add up to less handling and a low unit cost. Where continuous production of single sections or collected standard sections involving from 25,000 to 50,000 feet per 8-hr day is desired, roll forming is by far the most suitable of fabrication processes.

## Advantages and Limitations

Any ductile material can be formed from thicknesses ranging as low as 0.005-in. and up through 0.750-in. Height and width of section is limited only by the capacity of the machine, and length is limited only by length of the coiled stock. Flying cutoff units, used in conjunction with the roll forming machine, make it possible to cut sections to part lengths as short as 12 in.

The material to be formed directly affects the number of passes required, and design of tooling necessary to compensate for varying springback. Some materials "pick up" or gall, and this tendency affects the steel used for rolls and hardness of the rolls. Extreme galling sometimes requires chrome plating of the rolls to gain a specified section finish.

The hard or tempered metals often tend to crack or break at the radii. Progressive forming

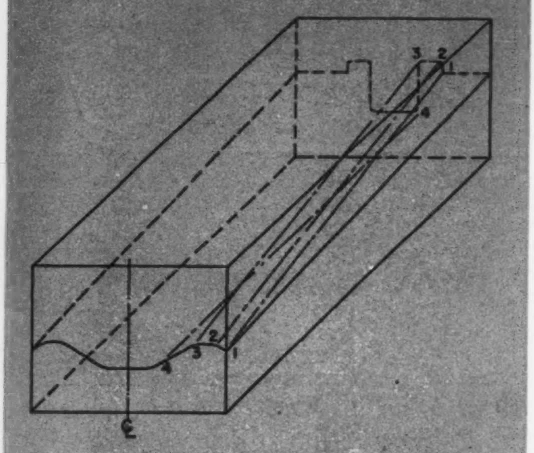


Fig. 2—Theoretical roll form layout. The shape represented by a cross section at any point could be used as a forming roll shape.

of each radius can reduce this tendency. It is practical to roll form a ductile material to a zero inside radius or a near sharp outside radius by forming the sharp corner into the strip before bending the matching side walls. The outside radius can then be coined almost square.

When considering design of a section whose probable quantities will warrant cold roll forming the designer may be guided by several general rules:

1. **Avoid extreme depth of section.** The available roll forming machine may control this factor.
2. **Avoid vertical side walls.** A slight angle is an aid to forming. This reduces metal scoring and unnecessary roll wear.
3. **Avoid blind corners or radii.** Forming accurate sectional dimensions is easier where the section can be controlled by the rolls.
4. **Design radii as large as possible.** The outside radius must ordinarily be at least metal thickness. The type of material being formed governs the possible inside bend radii. Ductile or untempered metals can be formed to zero inside radius, but tempered metals require greater radii to prevent cracking. Many handbooks give standard bend radii for materials based on brake forming or other methods of straight bending. As a "rule of thumb," these standard bend radii may be reduced one thickness for roll forming.

## Production Design Considerations

**Determining Number of Passes:** Theoretically, a roll form layout may be compared with a solid block of die material wherein is machined the shape to be formed, "faired" from flat to finished section, Fig. 2. If this block were divided into an infinite number of "slices," each slice could be converted into a roll and become a roll form pass. Obviously the more slices, or greater the length from flat to finished shape, the easier the progressive forming operation. Naturally, excess cost prevents the use of too many passes, so the minimum number of passes required to perform the forming operation must be determined.

A longitudinal forming angle of 1° 25′ has been found applicable as a guide in determining the number of roll passes required for simple shapes. In complex sections having multiple bends, each bend must be calculated individually for the number of passes required to form that bend. Then, after combining bends wherever practical, the total number of passes can be determined.

For simple shapes, the forming length of metal required to change from a flat cross section to the one desired will be equal to the height of the desired section or segment of a section multiplied by the cotangent of 1° 25′, or

$$F = 40.436\ H$$

where $F$ = forming length, in.; and $H$ = section height, in. For the 2-in. high channel shown in Fig. 3, $F = 40.436\ (2) = 80.872$ in.

The forming length divided by the fixed distance between shafts or spindles on the roll-forming machine to be used and raised to the next highest whole number gives the number of passes required to perform the bending.

To form the 2-in. high channel, Fig. 3, on a machine having a 15-in. horizontal distance between shafts or housings, the number of passes

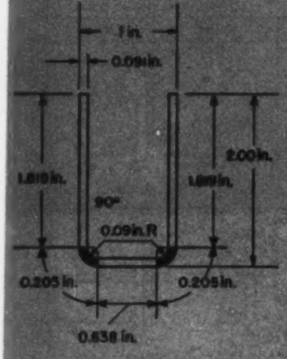


Fig. 3 — Typical roll-formed channel, and method of calculating width of strip necessary to cold roll-form it.

**Strip Requirements**

Bend allowance . . . . .

$B = (0.01743\ R + 0.0078\ T)\alpha$

$= [0.01743(0.09) + 0.0078(0.091)]90$

$= 0.205$-in.

| | |
|---|---|
| Developed width . . . . . . . . | 1.819 |
| | 0.205 |
| | 0.638 |
| | 0.205 |
| | 1.819 |
| | 4.686 in. |

required would be 80.872/15, or 5.39. Raised to the next highest whole number, the work requires six passes theoretically. The calculations are for one bend. It is obvious that the section is symmetrical and both bends can be accomplished at the same time.

For multiple bends on complicated shapes, the section must be broken down and each bend or pair of bends calculated individually to determine the number of passes required to form that bend. The total number of passes can then be determined by combining passes wherever practical.

The Z-section in Fig. 4 was designed to be formed about the pitch line or neutral axis and rotated 30 degrees from the horizontal plane. Following the principle of avoiding vertical side walls and by dividing up the required forming symmetrically, the most is gained from each roll pass. By calculation, the 1-in. high flange requires three passes to form; the ¼-in. high flange requires one pass to form. The bends on each side of the vertical centerline can be combined and formed simultaneously. To help thread the strip through the machine, a shallow form should be maintained in the first pass. For this reason, a starting pass is added to this section for a total of five passes.

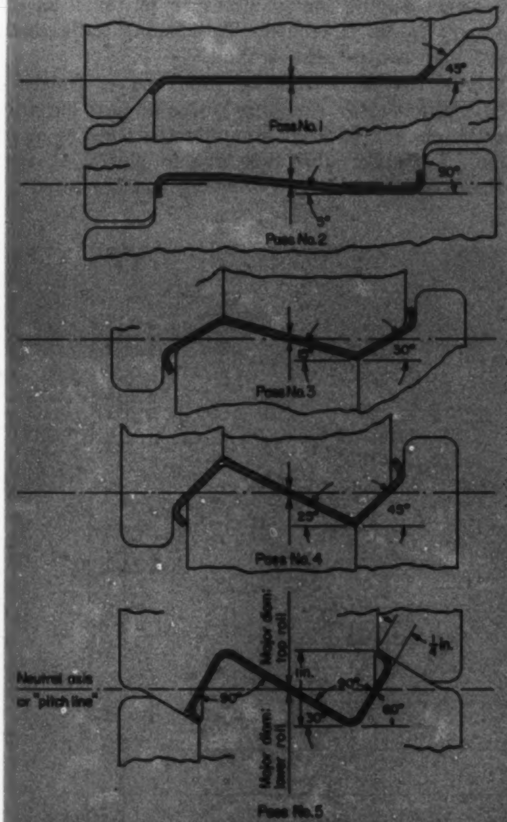


Fig. 4—A Z-section requiring multiple bends. Each bend must be calculated individually to determine the number of passes required.

Sometimes a section must be formed from a ductile metal with a zero inside radius and a near-sharp outside radius. The method is illustrated by Fig. 5.

**Calculating Material Requirements:** Given the dimensional cross section of the shape to be cold roll formed, it is necessary to calculate the developed width or "stretch-out" of strip material required. Straight segments on the cross section of the desired shape are added to the bend allowances, calculated from the following conventional equation to determine this width. The equation is applicable for use with all metals.

$$B = (0.01743\,R + 0.0078\,T)\,\alpha$$

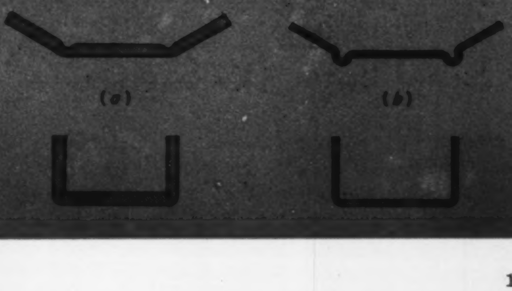
where $B$ = bend allowance, in.; $R$ = inside radius of bend, in.; $T$ = metal thickness, in.; and $\alpha$ = angle through which the metal is bent, degrees.

For example, to cold roll form a channel 2 in. high by 1 in. wide, Fig. 3, it would require a metal strip 4.686 in. wide.

**Roll Manufacture:** Rolls can be made from unhardened, low-carbon steel when relatively small quantities of simple shapes are to be formed. In many instances laminated plastic materials and cast iron are used as segments of rolls where extreme wear is not expected or as spacers between forming segments. Plastic laminated materials are often used to fabricate entire rolls for low production runs, although the final roll pass should always be made of steel.

For most shapes, however, and for longer tool life on large-production runs, rolls should be made from a good grade of oil-hardening tool steel, heat treated to Rockwell C 58 to 62. When the shape being formed is from hot-rolled unpickled steel, the roll material should be high-chrome, high-carbon steel to resist abrasive wear on the rolls.

Fig. 5—Method of obtaining a zero inside radius: *a*, by depressing or coining the strip in thicknesses over 0.032-in.; *b*, by roll-beading in 0.032-in. thickness or less. Since method *a* requires a depression of approximately 1/3 the material thickness, it it not recommended where structural corner strength is desired.


(*a*) (*b*)

For additional roll wear life and for improved part finish with elimination of "pick-up," rolls are often chrome plated after hardening and grinding.

Rolls are turned on lathes, allowing 0.010-in. of stock on all surfaces for subsequent grinding.

Segmental or split-roll construction can be employed if it will not interfere with satisfactory rolling of the part. Segmental rolls are more economical to manufacture, and they often can be used with spacers to form a variety of shapes and sizes. This reduces the tooling cost for any section which can be adapted to standardization and makes replacement of worn segments economical with minimum down time.

**Extra Forming and Production Operations:** Theoretically, if the rolls are designed properly and built accurately, guides or other corrective devices should not be needed between passes. There are occasions, however, where the machine shafts are too far apart to permit the material to thread or "fair" itself from one pass to the next. In such cases, plastic, fiber or kirksite guides are attached between passes to stools on the roll-forming machines.

Another important service performed by intermediate guides is that of doing actual work on the metal being formed. This work may range from simple overbending, compensation for springback, to actually forming reverse bends with horizontal idler or driven rolls. Fig. 6 shows a section using a horizontal idler roll setup for forming.

Another common use of the intermediate horizontal roll arrangement is in forming lock-seam tubing. The hooks are formed slightly open, and intermediate horizontal rolls "snap in" the hooks preparatory to sealing or crimping by the subsequent pass. Fig. 7 illustrates the use of these horizontal rolls between passes 6 and 7 and is also an example of lock-seam roll forming.

Springback is encountered to a varying degree, depending upon the design of the section, the properties of the metal, and the method of forming. It may be overcome by overforming in the next-to-last pass.

Cold roll forming machines may be equipped with a bending stand at the outfeed end, on which various yokes or shoes can be fastened. These can either apply deliberate coiling to the finished section or correct any tendency toward bending or twisting as the section leaves the final pass of rolls. If deliberate coiling is desired, adjustable coiling rolls designed either as idlers or as driven rolls can be provided, Fig. 8.

Just as nonconcentric rolls or machine shafts will cause metal stretching with resulting part waviness, this principle can be utilized to encourage a coiling tendency. In this case, the next-to-last pass of a section to be coiled finishes the shape dimensionally. The last pass incorporates a relief in the forming surface of the rolls to permit direct application of pressure to the area of the part to be stretched. The coiling rolls then "set" and control the coiling.

Where the section being produced is finished in straight lengths, shipping pieces or part lengths may be cut off without stopping the forming machine. A flying cutoff machine is placed at the outfeed end of the roll forming machine and a

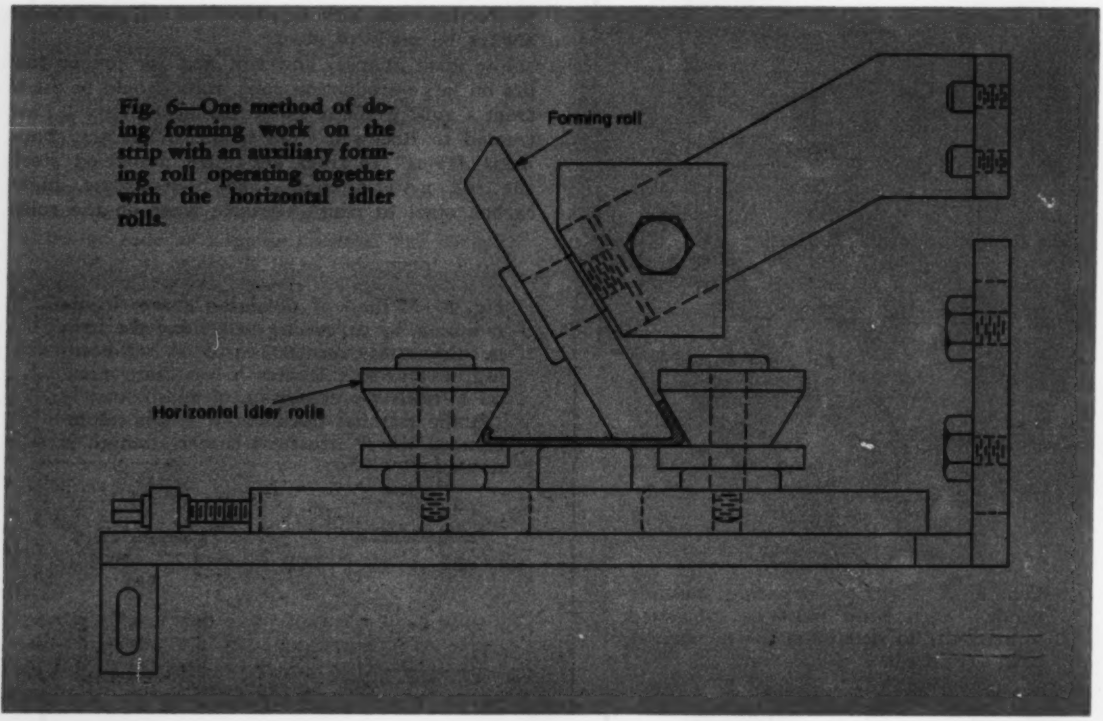


Fig. 6—One method of doing forming work on the strip with an auxiliary forming roll operating together with the horizontal idler rolls.

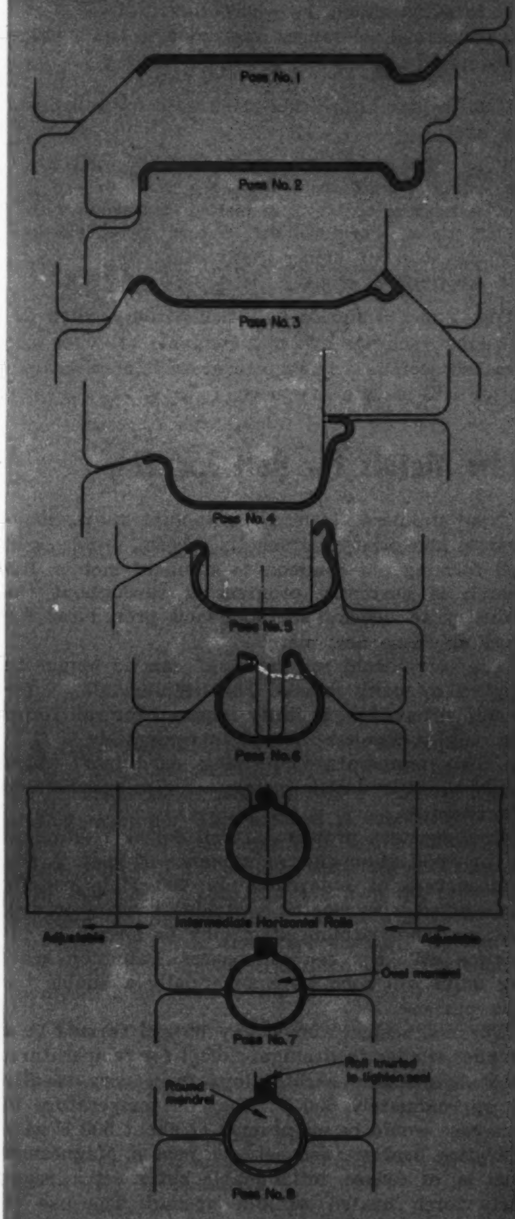


Fig. 7—Above—Layout of passes to roll-form a lock-seam tube. Horizontal rolls between Passes 6 and 7 snap in the section preparatory to locking the seam. Knurling the seam at the last pass tightens the lock.

mechanical device is mounted on the runoff table to actuate the flying cutoff trip mechanism. When closed sections, such as lock-seam tubing, are to be cut off, it is most practical to attach a high-speed saw to the head of the cutoff machine. Use of a saw prevents collapse of the section.

Cold roll formed sections, to serve their final purposes must generally have other production operations performed on them. Many of these operations, such as piercing, slotting, trimming, embossing, numbering and printing, can be incorporated into the roll-form tooling. In general, these operations are performed with rolls located ahead of the first forming pass. Piercing or slotting punches are mounted on a flat "male" roll, and the dies in a flat "female" roll. The roller dies are designed to punch the slugs completely through the metal strip. The designer must position such holes in even divisions of the circumferences of the roll pitch diameters. They may be arranged in almost any order within the capacity of the roll diameters.

When it is desirable to identify the section being rolled by marking with ink, the operation may be performed at either the infeed or outfeed end of the machine. If inking rolls are used at the infeed end, the ink must be of the quick-drying type to prevent smearing by the roll-form lubricant. An air hose attached to the machine helps dry the ink before the first forming pass.

Many production setups can combine other operations and other machines with the standard cold roll forming machine. Perhaps the most common of these occurs in the rolling of seam-welded tubing. The tubing is roll formed as a butt seam, cleaned, welded, burred and coiled or cut to length. The welder, with cleaning, sizing, straightening, and burring attachments, is mounted at the outfeed end of the roll forming machine.

Another unusual adaptation is the cold roll forming of shapes with special closed cross sections. First, a round lock-seam tube is rolled. Then a special rolling head converts the circumference

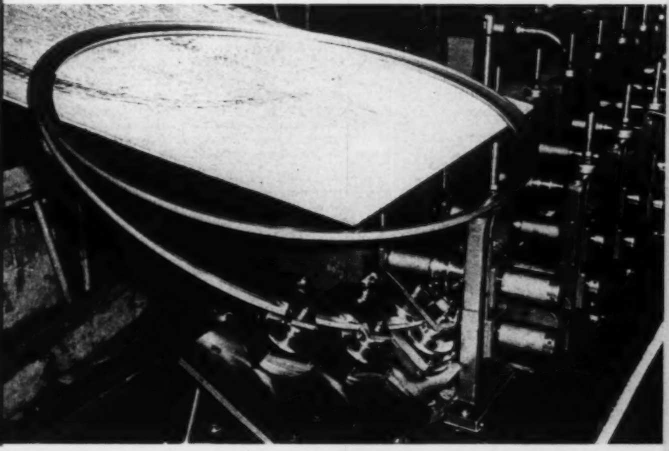


Fig. 8—Right—A hooked Z-section coiled to finished-part radius by adjustable idler coiling rolls. The hook on the stretched flange is formed in these idlers to help "set" the radius.

to the periphery of the cross section desired, Fig. 9.

This method is particularly advantageous if several closed shapes of different configurations are designed to have the same developed width or "stretch-out." The initial tooling expense is considerably reduced by having only one set of main rolls to form a tube and separate special head rolls to convert the tube into the desired shape.

The process is limited to comparatively shallow bends and sections without sharp radii or deep grooves. The special rolling head is set up similar to a regular roll pass and is simply a housing containing rolls adjustable for forming both in horizontal and vertical directions and combinations of each. This head is also designed for use as a tube straightener.

**Tolerances for Roll Forming:** Width of the metal strip to be roll formed is determined from the calculated stretchout of the section, as described previously. Tolerances on strip width when shoulder stops are incorporated in the roll design should be ±0.005-in. It is often necessary to install cutting rolls at the infeed end of the roll form machine to size the strip before forming. When shoulder stops are not used and part specifications are not critical, the strip width tolerance may be increased to ±0.015-in.

The most important requirement regarding the metal strip to be formed is freedom from camber. Camber in the strip constitutes a "built in" warp in the rolled section; it is extremely difficult to remove. Ordinarily mill tolerances on strip (2 in. in 20 ft) can be tolerated and corrected after rolling with the outfeed straightener. If the part specifications are severe, it is often desirable to remove the camber by stretching the strip before rolling. An elongation of approximately 2 per cent is required for this purpose.

Metal thickness tolerances, for best results in roll forming, should be ±0.0015-in.

Commercial tolerances applicable to the average roll-formed section are shown in Table 2.

**Table 2—Commercial Tolerances for Roll-Formed Sections**

| | |
|---|---|
| Piece length | ±$\frac{1}{16}$-in. using automatic cutoff. Standard lengths: 12 in. to 20 ft. |
| Twist | Not to exceed ½-deg per ft to a max of 5 deg except where twist can be corrected with light hand pressure. |
| Cross-section dimensions | ±$\frac{1}{64}$-in. on fractional dimensions (to 0.001-in.); 0.015-in. on closed decimal dimensions. |
| Angles | ±1 deg up to 0.064-in.; ±2 deg up to 0.125-in. |
| Straightness | ⅛-in. in 12-ft lengths except where bow can be corrected with light hand pressure. In no case more than ¼-in. in 12 ft. |

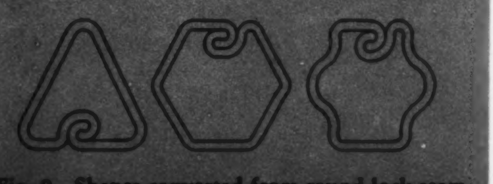


Fig. 9—Shapes converted from round lock-seam tubing with a special rolling head.

**Lubricants:** Lubricants often used for roll forming are:

1. A solution of one part soluble oil with five parts of water.
2. A mixture of 1½ lb of melted lead oleate with 1 gal of warm solvent in turn mixed slowly into 50 gal of thinner or solvent.
3. Any solvent alone.

Items 2 and 3 should be specified only when degreasing facilities are not available or when the finished section is to be primed or painted. Evaporation will leave a dry piece.

## New Metals for Roll Forming

New stainless steels, the titanium alloys, magnesium and other new metals present problems in roll forming not common to standard metals. Research is currently progressing throughout the industry to develop methods and procedures for working these new metals.

The term "cold roll forming" can no longer be applied to many metals. The titanium alloys, for example, have the ductility required for roll forming only at temperatures of approximately 1000 F. At this temperature, forming conditions which apply to other ductile metals are also satisfactory for titanium.

The greatest problem in roll forming titanium is the application and maintenance of heat. A roll temperature of approximately 400 F is usually maintained with electric cartridge heaters or disk heaters. The titanium strip may be heated by induction coils between roll passes. Induction heating units will soon be commercially available for this purpose.

The magnesium alloys may be roll formed in a manner similar to titanium except for temperature. Most magnesium sheet alloys form very readily at approximately 650 F. The roll temperature in this case would be maintained at about 500 F with induction heaters used between passes. Magnesium dust is, of course, inflammable but sheet is regularly torch heated without mishap. The use of infra-red lamp heaters has also been successfully applied to forming magnesium sheet.

Thoriated magnesium is a new alloy gaining popularity because of strength, light weight and high-temperature properties. Forming properties of this material are the same as for other magnesium alloys except that thoriated magnesium is mildly radioactive. Although this is not harmful in a well-ventilated area, standard procedures governing the handling of such materials must be applied.

Metals which require heat for roll forming have several apparent disadvantages. These are largely offset by the reduction of springback, which is negligible at the elevated temperatures, and the possibility of forming much smaller bend radii.

# *How to use*
# Adding Machines as Calculators

7
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By C. M. Gillespie
*Assistant Engineer*
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ARITHMETIC problems of addition, subtraction, multiplication or division can often be carried out on a "ten-key" type adding machine. This method is especially useful when an electric calculator is not available and a slide rule will not provide sufficient accurary.

In essence, all calculators are simply specially equipped adding machines. Therefore, it is only necessary to fill in the steps that are automatically handled by an electric calculator. Six factors involved in developing this process are:

1. The fundamental basis for all mathematics is

## Addition

. . . when the number of columns exceeds the capacity of the machine.

PROBLEM: Add

23456789567
34567895432
56789567854
56437867543

SOLUTION: The numbers can be broken into two parts and each part added:

| | |
|---|---|
| 23456 | 789567 |
| 34567 | 895432 |
| 56789 | 567854 |
| 56437 | 867543 |
| 3 | 120396 |
| 171249 | |
| 171252 | 120396 |

## Multiplication

. . . when the problem exceeds the ordinary capacity of the machine.

PROBLEM: Multiply 23456 by 34567.

SOLUTION: Any two numbers can be directly multiplied together by an adding machine if the total number of digits does not exceed the number of columns the machine was built to handle. This example has a total of ten digits. It could be handled directly by a ten-column adding machine. If, however, only a seven-column machine is available, the problem must be broken down:

| | | |
|---|---|---|
| 23456 | 23456 | 23456 |
| 3 | 45 | 67 |
| 70368 | 1055520 | 1571552 |

Then the figures are arranged in proper columns and added:

| | |
|---|---|
| 157 | 1552 |
| 10555 | 20 |
| 70368 | |
| | 3552 |
| 81080 | |
| 81080 | 3552 |

Since each factor has only five significant digits, the product usually would be rounded off to 81080. The decimal point depends on the problem, as in the operation of a slide rule.

If preferred for speed, the numbers can be rounded off at the first stage, thus:

$$23456 \times 67 = 1571552 \text{ or } 15716$$

This can be added to the product of 23456 × 45 by adding 15716 before taking a total:

$$(23456 \times 45) + 15716 = 1071236$$

which can be rounded off two places to give 10712. This, in turn, is added to the product of 23456 ×3 to obtain 81080. Again, the decimal point is found by estimation as in the case of a slide-rule manipulation.

matching. (Shepherds may have used this method in accounting for their sheep. By matching one stone in an old pelt bag for each sheep, it was possible to tell when they were all in the same fold.)

2. Counting was derived from matching.
3. Addition was derived from counting.
4. Multiplication is simply the addition of one number another number of times.
5. Subtraction is the reverse of addition.
5. Division is a special case of subtraction. Dividing 100 by 5 is, in effect, finding the number of times 5 can be subtracted from 100.

These six factors are the bases for extending use of the adding machine. Many shortcuts can be derived from them.

The manual that comes with the adding machine shows how to add, subtract and multiply. Using this and the six factors, it is possible to extend use of the common adding machine to such problems as division, multiplying numbers that seem too large for the machine, or adding numbers that have more columns of digits than the machine is built to handle.

The adding machine can not only substitute for an electric calculator, it can also be helpful in checking slide-rule work. One may make the same mistake over and over again, but by using a different tool he may find the error without wasting more time.

A few minutes spent learning how to get the most out of an adding machine may mean hours saved when time is at a premium. The accompanying examples illustrate the possibilities.

## Division

The electric calculator has a device which automatically determines how many times one number can be subtracted from another. The number of times is the quotient and is registered on the appropriate cyclometer. In using an adding machine for the same purpose, a slide rule is used to find the trial divisor, thus indicating how many times to pull the handle. The remainder is the immediate goal. After the remainder is found, the process is repeated.

PROBLEM: Divide 23456 by 3456.

SOLUTION: By slide rule the trial divisor is found to be 67 for the first two places. Thus, on a seven-column machine, 345600 is subtracted 6 times and 34560 is subtracted 7 times, as follows:

$$\begin{array}{r} 2345600 \\ -345600 \\ -345600 \\ -345600 \\ -345600 \\ -345600 \\ -345600 \\ -34560 \\ -34560 \\ -34560 \\ -34560 \\ -34560 \\ -34560 \\ -34560 \end{array}$$

leaving 30080. If only four significant digits are required, 30080 may be divided by 3456 on a slide rule and read only two figures for the next two digits. It is found to be closest to 87. The entire quotient is then 6787, and the decimal point is found by inspection.

# Tips and Techniques

## Computing Segment Areas

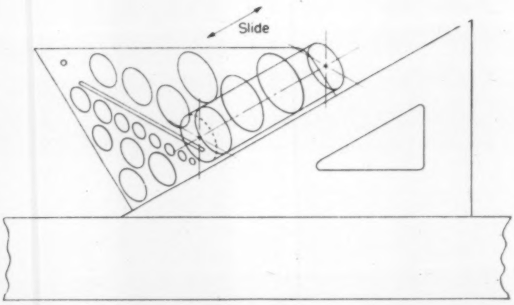
Conventional methods for determining the area of a segment of a circle are rather lengthy when compared with an approximate formula,

$$A = \frac{2ch}{3} + \frac{h^3}{2c}$$

which is correct to within 1 per cent or less.—ARNE BENSON, *Sanders Associates Inc., Nashua, N. H.*

## Drawing Ellipses

An isometric ellipse template such as the Rapidesign No. 123 may be more useful if it is cut in half to provide edges parallel to the minor axes of the ellipses. Halves of the template may then be moved along a 30-60 degree triangle so that ends of a shaft or any cylindrical shape can be drawn in a minimum of time and in perfect alignment.—THOMAS D. REID, *Aeronautical Communications Equipment Inc., Miami, Fla.*



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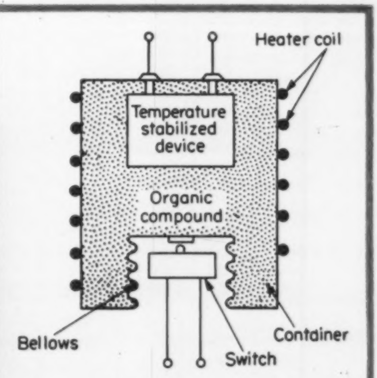

Fig. 1—Typical components of a fusion-temperature controls.

**Looking for a way of developing high-level, precisely modulated forces for a control-system application? The remarkable volume expansion that results when certain organic compounds are melted provides such an action. Exact nature of the isothermal fusion process is reviewed in this article, and practical suggestions are given for the design of fusion-operated bellows actuators, temperature controllers and constant-temperature baths.**

# Fusion-Temperature Controls

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OBSERVATION of the *fusion* process—which is what happens when a solid melts to the liquid phase—reveals two salient facts: (1) the melting substance experiences a considerable change in volume, and (2) temperature of the solid-liquid mixture remains fixed at the melting point until the fusion process is completed. Such change-of-phase effects have found useful application in the design of precision temperature controls.[1] Development efforts along these lines, however, have been quite limited, especially when contrasted with the work done on controls making use of the much smaller volume coefficient of expansion of liquids and gases. Literature on the subject, moreover, has not stated specifically the types of compounds that can be used, nor has it placed much emphasis on the isothermal nature of the fusion process.[2]

Changes in volume that occur during fusion are quite large—amounting on the average to about 10 per cent of initial volume. Furthermore, the energy available from this process is very high. To achieve equivalent mechanical action with a bimetal-operated controller, 5000 times as much material would be required as in the fusion temperature device. Such volume changes can be used to actuate mechanical components such as bellows and switches, valves, or dampers. By adjusting the position of the moving element—the bellows, for example—sensitivity of such elements can be controlled over short ranges. The nature of the compound fixes its exact melting point.

The design function of the fusion-temperature control unit will, of course, determine its exact configuration. But, in general, components of the device, illustrated in Fig. 1, are: (*a*) a sealed container enclosing both the compound and the device to be temperature stabilized; (*b*) a bellows mounted so as to move with volume changes in the control compound; and (*c*) a heater which holds the compound at its melting point, the heater being turned on and off by a switch actuated by the bellows.

In the design of such a unit, certain specifications are usually set on the nature of the control compound, its volume, the fraction of the compound that is in liquid form during set-point operation, bellows travel, input to the heater, etc.

In following sections of this article, these design

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[1] References are tabulated at end of article.

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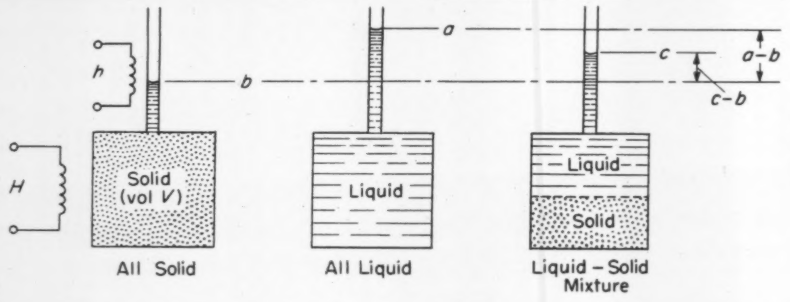


Fig. 2 — Sight-glass method for determining initial liquid fraction in control unit.

**Nomenclature**

$A, B, K$ = Constants
$A_e$ = Effective bellows area, sq in.
$a, b, c$ = Liquid level in sight glass, in.
$C$ = Heat of fusion, joules per cu in. ($= 68.6\ c\rho$)
$c$ = Heat of fusion, cal per gm
$K_r$ = Rate of heat transfer, watts per deg C
$M$ = Slope, deg C per cent
$T$ = Temperature, C
$V$ = Volume, cu in.
$W$ = Power, watts
$X$ = Mixture ratio, per cent
$x, y$ = Bellows stroke, in.
$\alpha$ = Fraction of container volume in liquid phase
$\beta$ = Coefficient of volume expansion, per deg C
$\delta$ = Fractional change in volume during fusion
$\rho$ = Specific gravity

Subscripts

$l$ = Liquidus
$s$ = Solidus
$o$ = Intercept

points are considered, and practical suggestions on the construction of such a unit are outlined in detail.

**How to Select the Control Compound:** Choice of the compound that will be used for each application depends in the main on its melting point. A sharp melting point is required, but not all organic compounds can be purchased at reasonable cost with a high degree of purity. Usually the melting point specification is guaranteed only to 1 degree (C). Where the desired melting characteristics cannot be obtained with a pure organic compound, a two-constituent mixture may be used (see Appendix).

The change in volume experienced by organic compounds is quite large, averaging about 10 per cent. For some compounds, for example anthraquinoe, volume expansion may be as high as 17 per cent. After a compound that appears suitable for use in the fusion temperature control has been selected, its volume expansion characteristic may be checked last, since this quality is normally high enough for all practical applications.

When checking a compound for suitability from the long list of those available, certain additional characteristics should also be considered:

(1) Corrosiveness.
(2) Flash point.
(3) Toxicity.
(4) Solvent action.
(5) Absorption of air.
(6) Electrical conductivity.

Although some organic compounds may be bland enough at room temperatures, during the filling process they must be heated, and their fumes and solvent power may then become a hazard to personnel. Typical are the aromatic compounds which should not be melted unless adequate ventilation is maintained. Information on the toxicity of the materials that might be comtemplated for use in fusion-temperature controls is of great value.[3]

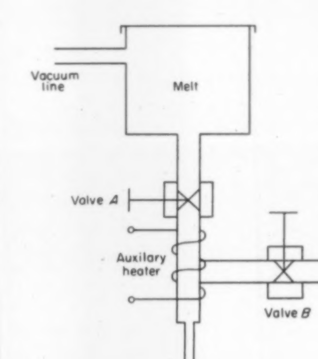


Fig. 3—Apparatus for filling fusion temperature control container.

**Liquid-Solid Mixture:** A parameter of great utility in the investigation of fusion-temperature controls—due principally to its use in design formulas—is the quantity $\alpha$, which is defined as the fraction of the control compound that is in the liquid phase at any instant. Consideration of Fig. 2 will provide an insight into the meaning of this term. The sketches also schematically illustrate a method that can be used to fill the fusion-temperature control with the initial liquid-solid mixture.

The three sketches (Fig. 2) show the compound occupying the controller volume in the completely solid state, the completely liquid state, and the liquid-solid state, respectively. State of the compound (liquid or solid) is determined by the current that is allowed to flow through the heater $H$. The compound in the sight glass is held in liquid form in all three cases by the axiliary heater coil $h$.

It is obvious that if the level in the sight glass moves from $b$ to $a$ when the solid compound is completely melted (full heater current), then the value $(a-b)$ is proportional to the total volume expansion that occurs.

Assume next that the current to heater $H$ is adjusted to hold the liquid in the sight glass at some level $c$, intermediate between $a$ and $b$. It follows that, if $(a-b)$ is the total volume expansion for complete melting of the compound, then expansion $(c-b)$ indicates that fraction $(c-b)/(a-b)$ of the original compound volume $V_o$ has now melted. Therefore, for this particular liquid-solid mixture, the fraction of the compound in the liquid phase is

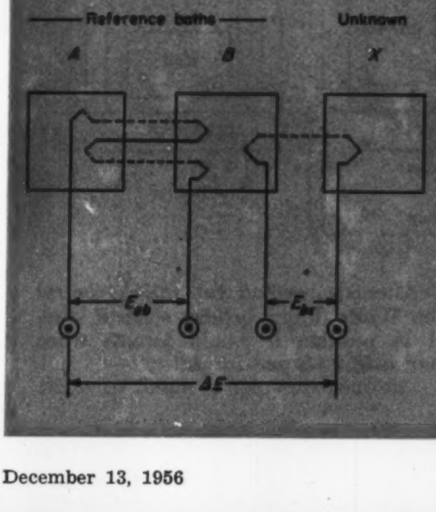
$$\alpha = \frac{(c-b)}{(a-b)} \qquad (1)$$

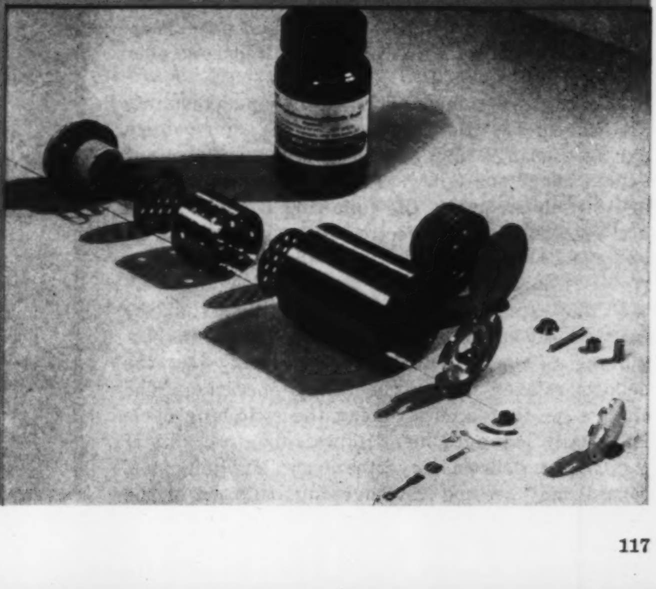
when the current $i$ flows through the heater.

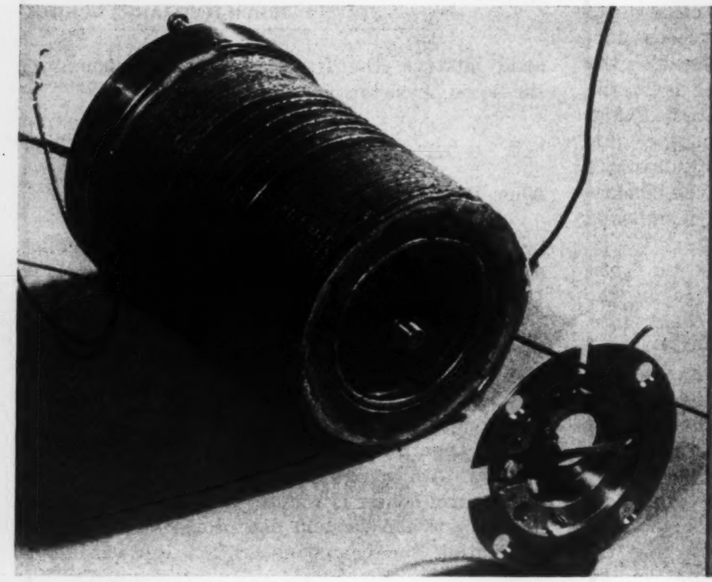
**Filling Apparatus:** The preceding discussion of the term $\alpha$ illustrates the operating principle of the filling apparatus, Fig. 3. In addition to giving a convenient means for setting $\alpha$ at the operating point, the filling apparatus performs several other essential functions: (1) It melts the compound; (2) It deaerates the compound; and (3) It drives the compound into the control container.

The apparatus in Fig. 3 was used to fill controllers with naphthalene. In this arrangement, the control heater is connected to a variable transformer and the vacuum line provides a means for deaerating the compound. When the vacuum is released, the compound is driven down into the control container. After the temperature control unit is filled, valve $A$ is closed and valve $B$ opened. With both heater circuits still in operation, the liquid level $a$ is marked on the sight glass. The control heater is then shut off, and the melt is allowed to completely solidify. New level $b$ is then marked on the sight glass. Finally, the current to the control heater is adjusted to stabilize the sight-glass liquid level at $c$. Equation

**Fusion-temperature control apparatus offers a compact cold-junction reference bath for multiple thermocouple installations. In the sketch, a cold-junction reference and temperature monitor system is illustrated. Compounds in containers *A* and *B* and junction metals are chosen so that voltage $E_{ab}$ generated between the two references will balance voltage $E_{bx}$ generated between junction x and one of the references. The two voltages oppose each other and produce the error signal E. Photo shows a thermocouple reference designed to hold ± 0.005 C with as many as nine junctions buried in the container.**







**Fusion temperature control devices — because they are rugged, self-contained and use no tubes or sensitive relays—are well suited to military application. A temperature stabilized gyroscope installation is shown here. To facilitate removal of the gyro from the temperature controller, the controlling compound is sealed in a double-cup arrangement. Despite the open-ended design, temperatures hold to ± ½-C down to ambients of −60 C.**

1 then gives the quantity $\alpha$. The control container is then sealed off while the bellows element is in the relaxed position. An alternate arrangement for the filling apparatus is shown in Fig. 4.

**Selecting the Controller Volume:** Mechanical energy derivable from the melting process is, in most instances, limited by the strength of the enclosure. It should also be recalled that the melting point of the compound when subjected to very high pressures may be raised to the point where the desired tolerance on melting temperature is exceeded. To minimize the possibility of such an effect, the designer may choose a rugged, long-travel bellows and a long-travel switch. In most applications, proper overtravel should be built into the bellows and switch arrangement to ensure that all the compound can be melted without rupturing the control. Consideration of bellows area and switch travel desired leads to a simple expression for the change in volume $\Delta V$ that the compound must undergo during the switching cycle. As is shown subsequently, such an expression can be solved to give the required controller volume.

For a given compound the following constants are known: $\delta$, the fractional change in volume during melting; and $\beta$, the volume coefficient of expansion of the liquid. For the assumed bellows and switch assembly, the following characteristics are known: $A_e$, the effective bellows area; $x$, the operating travel of the switch; and $x_{max}$, the overtravel in the system.

It was explained in a preceding section that the fraction of liquid $\alpha$ in the controller at the beginning of each switching cycle is set with the bellows relaxed during the filling operation. The change $\Delta\alpha$ that occurs during the switching cycle is usually bounded as follows: $0.5 < \alpha < 0.8$. If $\alpha < 0.5$, the bellows may freeze up; and if $\alpha > 0.8$, control may become less sharp due to some of the liquid having a gradient across some part of the volume. Generally, $\alpha = 0.7$ is considered to be about right.

Total change in the volume of the compound due to a change $\Delta\alpha$ in the fraction of liquid present can be set equal to the total volume displacement of the bellows, or

$$\Delta V = (\delta)(\Delta\alpha)(V) = A_e x \tag{2}$$

Basis for this equation becomes intuitively clear if it is recalled that any increase in the quantity of liquid in the container is accompanied by a

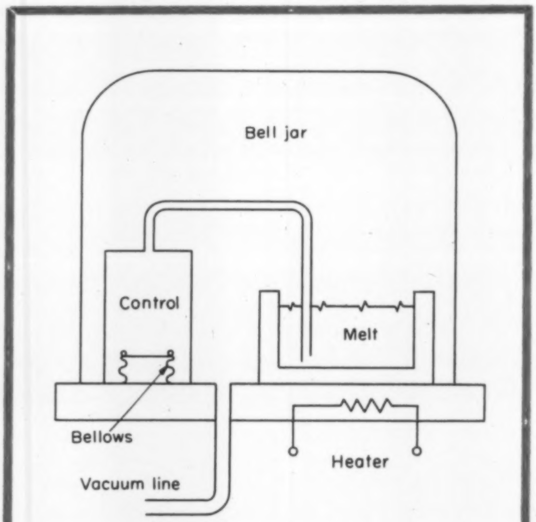


Fig. 4—Alternate method for filling control container. While filling, bellows element is restrained in position it would assume when compound is in all-liquid form.

proportional reduction in the quantity of solid. Total volume change is therefore equal to the increase liquid volume $(\Delta\alpha)V$ multiplied by the term $\delta$.

If the possibility exists that heat will be added even after the entire compound is melted, bellows overtravel must be provided to allow for the volume coefficient of expansion of the completely liquefied compound. In this case, total anticipated volume expansion is equated to $A_e x_{max}$.

With the aid of Equation 2, therefore, the designer may select a controller volume $V$ which gives the required travel of the bellows.

**Predicting the Switch Cycling Rate:** The formulas derived in this section merely serve to clarify certain aspects of the design problem. They are qualitative in nature, since the effective rate of heat transfer $K_T$ of the control is difficult to compute in advance. In practice, a model of the device is built and the value of $K_T$ is determined by experiment.

The temperatures that are usually specified are:

$T_2$ = the highest ambient to be encountered;
$T_3$ = the lowest ambient to be encountered; and
$T_1$ = the overtemperature specified $(T_1 > T_o)$.

A compound will be chosen with a fusion temperature $T_o$ that is as high as possible. The net heat that is supplied to the system is $(W + W_o)$, where $W$ = power supplied by heater, and $W_o$ = power lost by device continuously.

When the lowest ambient temperature $T_3$ occurs, the heater should be on continuously. Therefore

$$W + W_o = K_\tau\ (T_o - T_3) \tag{3}$$

Likewise, when $T_2$ occurs, the heater should never turn on, and

$$W_o = K_\tau\ (T_o - T_2) \tag{4}$$

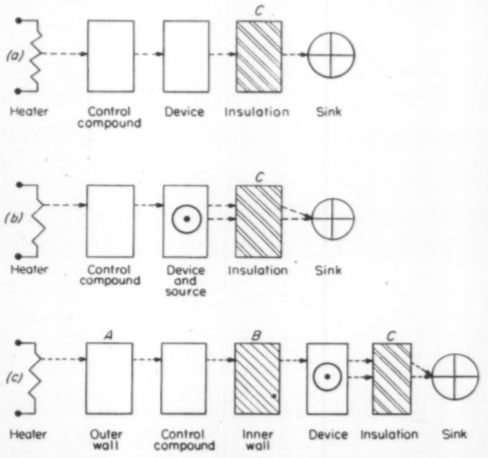


Fig. 5—Possible "thermal-circuit" configurations for fusion temperature controls.

At any ambient temperature $T$ between these limits, the switch will cycle for a period on $\tau_{on}$ and a period off $\tau_{off}$. The total period is therefore

$$\tau = \tau_{on} + \tau_{off} \tag{5}$$

During each of these on-off cycles the compound either receives or yields heat according to its latent heat of fusion $C$ and the volume $\Delta V$ that changes state. The energy equations for these processes for some ambient $T$ are

$$\tau_{on}\ [(W_o + W) - K_\tau\ (T_o - T)] = c(\Delta V)$$
$$\tau_{off}\ [W_o - K_T\ (T_o - T)] = c(\Delta V) \tag{6}$$

Combining Equations 3 through 6 into a single expression and taking the derivative of $\tau$ with respect to $T$, the minimum period (maximum switching rate) becomes

$$\tau_{min} = \frac{4\,C(\Delta V)}{W} \tag{7}$$

This factor may be used in conjunction with the life of the switch to determine how much liquid the control should contain in the event switch life is an overriding consideration.

**Practical Design Considerations:** If a control could be built which completely surrounds the device that is to be temperature stabilized, the design task would be greatly simplified. In practice this is not possible because there are always electrical connections that pierce the wall of the container. The existence of leads and headers is cause enough for temperature gradients to appear, and these gradients are dependent on the ambient temperature. The sketches in Fig. 5 symbolically represent three arrangements for the fusion temperature control and show the heat paths from the heater to the ambient sink.

The simplest situation is depicted schematically in Fig. 5*a*. Here the temperature gradient problem can be minimized by improving the insulation value in wall $C$. In Fig. 5*b* the stabilized device also has an input which must be dissipated, and there is a limit to the amount of insulation that can be tolerated. It may be argued that a higher melting point compound could be employed; there is, however, an upper temperature limit for the materials employed in the construction of the device itself. In Fig. 5*c* a more difficult problem is posed. Assuming that the device to be stabilized cannot be submerged in the liquid, there will be two walls through which heat must flow. In this installation, as in the other arrangements, satisfactory operation of the fusion temperature control requires careful attention to the following thermal-circuit design points:

(*a*) ***Inner Wall Thickness:*** The metal wall between the temperature control compound and the device should be as thin as possible. It should be pure copper. Fins should extend through the organic control compound, since large gradients will appear in these liquids unless this precaution is taken. Naturally, the surface area of the copper in contact with the liquid should also be as large as possible.

(*b*) *Insulation Around Ports:* Rather than allow heat losses to be dissipated through the headers and leads, it is best to insulate these positions as much as possible. If heat losses are dissipated through a control compound which is a mixture of liquid and solid states, no temperature gradients can exist across the device. In practice there is room for only meager insulation over the electrical connectors, and some gradient can be expected to occur. Where space is limited, low conductivity metals will aid the designer in reducing the conductivity from inside to outside. Table 1 is a list of some of the available alloys that have very low heat conductivities.

**Table 1—Low Conductivity Alloys**

| Type | Thermal Conductivity (per cent copper) |
|---|---|
| *Stainless* | |
| AISI Type 302 | 1.6 |
| AISI Type 420 | 2.5 |
| AISI Type 410 | 2.7 |
| AISI Type 430 | 2.6 |
| AISI Type 446 | 2.1 |
| *Bronze* | |
| ASTM B144 Alloy 3A | 12 |
| ASTM B96 Type A | 10 |
| ASTM B206 Alloy B | 7.5 |

(*c*) *Placement of Heater:* The most sensitive control is obtained when the heater is in the same container with the control compound. Installation of the heater on the outside of the container is acceptable so long as there are no short conducting paths leading from the heater to the device. In other words, all heat absorbed or dissipated from the control should pass through the control compound. The pitch or density of the heater should be increased near openings into the cavity. Heat must be conducted readily to the actuating bellows and it is best to allow areas around the bellows to warm up first.

## Appendix

**Two-Constituent Mixtures:** Although it is desirable to use the purest compounds obtainable in a fusion-temperature control, there are often valid reasons that permit violation of this rule. For example, some controller applications may tolerate a broad melting band. In other instances it may be impossible to find a chemical with just the right characteristics and melting point. In such events, the eutectics offer the designer a wider choice of substances and a wider range of melting points than do the unadulterated compounds.

Data on phase diagrams are found throughout the literature.[4] The most expeditious approach will be to pick a compound which melts at a temperature closest to the desired melting point. Next, a phase diagram can be plotted from cooling experiments. Choice of solutes can be made from the isomers or other compounds with similar molecular structures.

Two typical examples are shown in Figs. 6 and 7. The phase diagram, Fig. 6, is typical of a compound which is soluble in its solid phases.[4] It should be noted that the liquid plus solid phases (shaded areas)

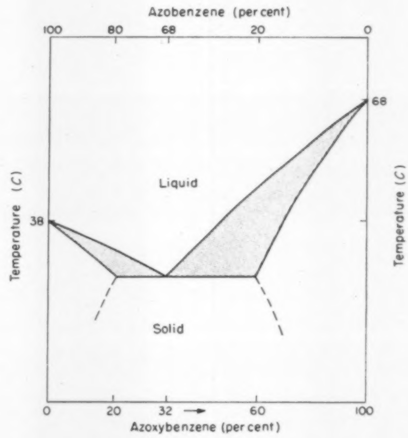


Fig. 6—Phase diagram representative of two-constituent compounds that are soluble while in the liquid phase. Shaded areas represent liquid plus solid phases.

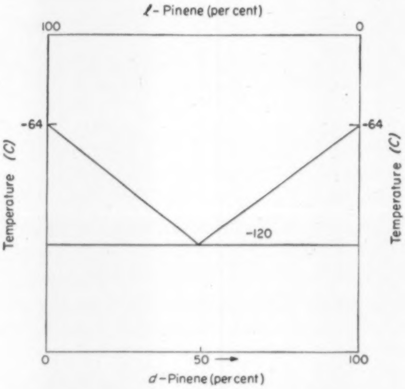


Fig. 7—Phase diagram for compound with no solubility in solid phase.

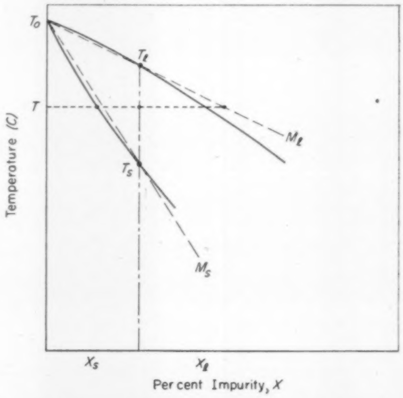


Fig. 8—Approximation of phase diagram by straight lines.

are relatively narrow. Thus, there will be a narrower temperature range in which the bellows will complete its full travel.

In Fig. 7, a system is shown for which there is no solubility in the solid phase.[5] This is the worst situation, for it can be shown that in a control with $\alpha = 50$ per cent large changes in temperature are required before the bellows will move through its full travel. For example, if the impurity (l-pinene) is 5 per cent, the melting point is depressed only 6.4 degrees (C), while the control range is 50 degrees wide.

The designer will need to know how the bellows moves as a function of temperature. This expression can be derived if a few points on the phase diagram in the region in question are known. Fig. 8 is a typical example where straight lines are used to approximate the solidus and liquidus. Melting point $T_o$ of the pure compound may be used, and the points $T_s$ and $T_l$ may be determined by experiment. This derivation treats the case for small impurities, but other cases, such as those near a eutectic region, can be handled in an analogous manner.

Let the slopes of the approximate lines be $M_s$ and $M_l$. These lines have the equations

$$T = M_l\, X_l + T_o$$

$$T = M_s\, X_s + T_o \qquad (8)$$

Now, if the lever rule is applied, the percentage liquid existing at temperature $T$ may be found. It is this change of solid to liquid that causes the bellows to move proportionally by some factor $K$, or

$$y = K\,\frac{X - X_s}{X_l - X_s} \qquad (9)$$

## Table 2—Fusion Characteristics of Two-constituent Compound

| Azoxybenzene in Mixture X (per cent) | Melting Range $T_l—T_s$ (C) | Melting Point Depression $T_o—T_l$ (C) |
|---|---|---|
| 1 | 0.10 | 0.70 |
| 5 | 1.25 | 2.40 |
| 10 | 1.70 | 5.30 |
| 20 | 3.20 | 10.60 |

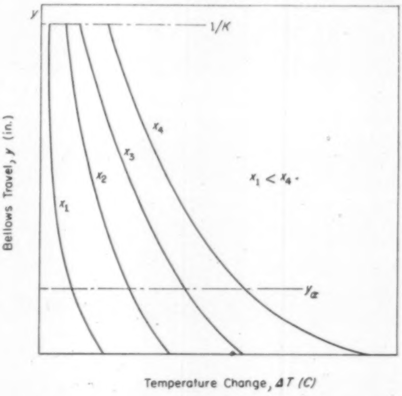


Fig. 9—Bellows travel as function of $\Delta\ T$ (Equation 10).

By substituting Equation 8 into 9, an expression for the bellows travel $y$ can be found. If this equation is nondimensionalized, it will have the form

$$y = A + \frac{BX}{\Delta T} \qquad (10)$$

where the variables have the values

$$\Delta T = T_o - T$$

and the constants have the values

$$A = \frac{K}{1 - \left| \dfrac{M_s}{M_l} \right|}$$

and

$$B = \frac{K}{1/M_s - 1/M_l}$$

This function can be represented by a family of equilateral hyperbolas plotted in Fig. 9. In the domain

$$X_s \leq X \leq X_l$$

the value of $y$ lies in the region

$$o \leq y \leq 1/K$$

Finally, if $\alpha$ is set at some particular value,

$$\frac{2\,X}{1/M_l + 1/M_s} < \Delta\, T_\alpha < (T_o - T_l) \qquad (11)$$

and there is a lower bound for $y = y_\alpha$.

When complete phase separation occurs, such as that shown in the diagram of Fig. 7, the value of $y$ may be found by noting that

$$\text{Limit}\; y = \frac{KM_lX}{\Delta T}$$

$$M_s \rightarrow \infty$$

The explanation of Fig. 9 is simple enough. As more impurity is introduced into the compound of the control, the bellows will move during a greater range of temperature changes. The line $1/K$ is the liquidus condition on the phase diagram, and the line $y_\alpha$ is the condition where the bellows begins to move. If more compound is used—that is, $V$ is increased—and $\alpha$ is also increased, the line $y_\alpha$ can be raised. This will offset the range of melting that would be incurred by adding impurity.

An example will now be given for the system shown in Fig. 6. Assuming that the azobenzene is the primary constituent the following data can be found: $T_o$ = 68 C; $M_l$ = 53.2 C per mole fraction; and $M_s$ = 88.3 C per mole fraction.

Let $\alpha = 50$ per cent and $K = 1$. Then substituting these factors into Equation 10 gives the results of Table 2. It is seen that the melting range is not so severe as in example given for the d-pinene system.

Not all phase diagrams will be as simple as the examples included here. However, these few suggestions may spur wider application of this phenomenon in many fields of temperature control.

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3. N. I. Sax—*Handbook of Dangerous Materials*, Reinhold Publishing Corp., N. Y.
4. J. H. Hildebrand and R. L. Scott—*Solubility of Nonelectrolytes*, Reinhold Publishing Corp., N. Y.
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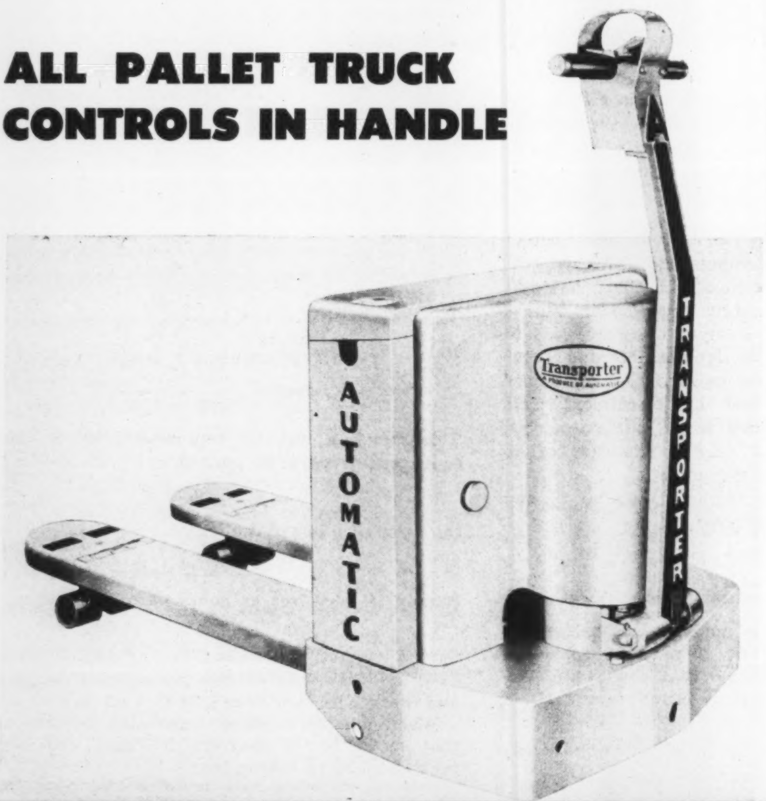
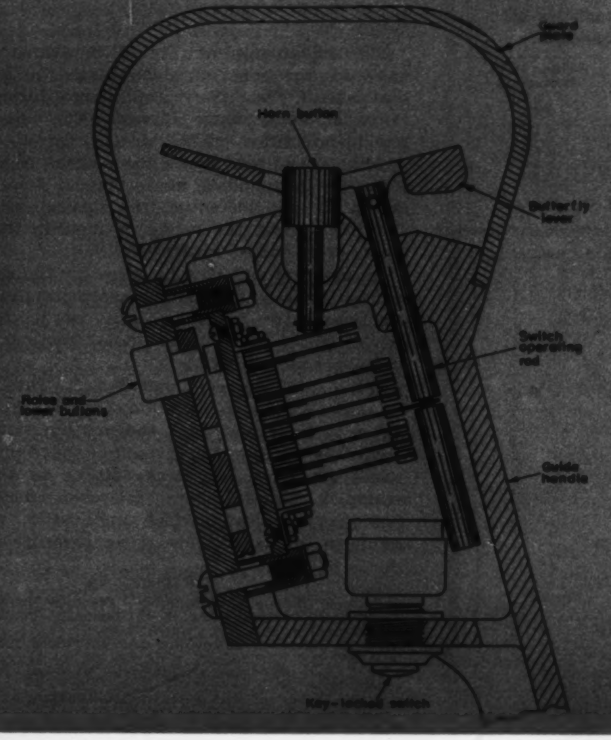
# ALL PALLET TRUCK CONTROLS IN HANDLE

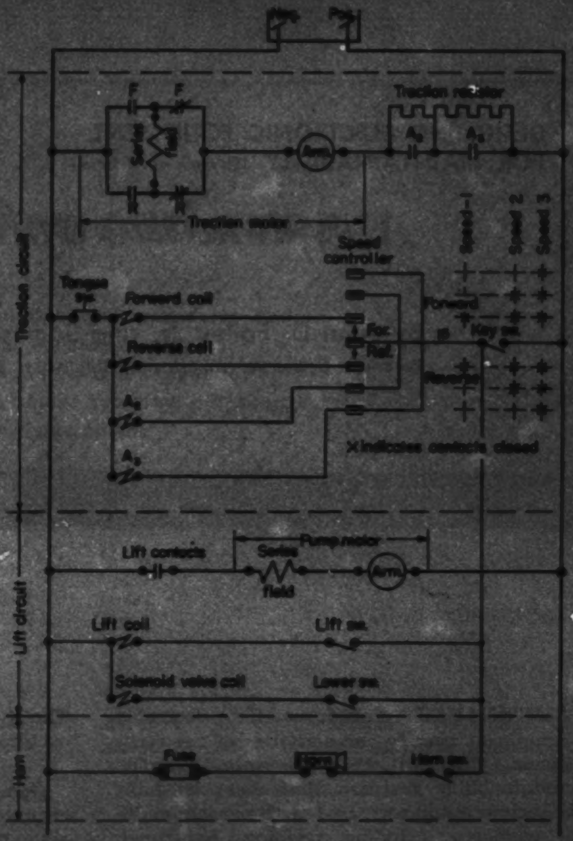

AUTOMATIC
TRANSPORTER
Transporter

ALL controls of a recently introduced pallet truck are conveniently grouped on or operated by the steering handle. Produced in 4000 and 6000-lb capacity models by the Automatic Transportation Co., these new Transporters are only 21½ in. long, excluding the pallet forks. Controls conveniently located on the handle include a horn button, pallet lowering and raising pushbuttons and a forward - reverse and speed-selector switch. Three speeds are available for reverse as well as forward travel.

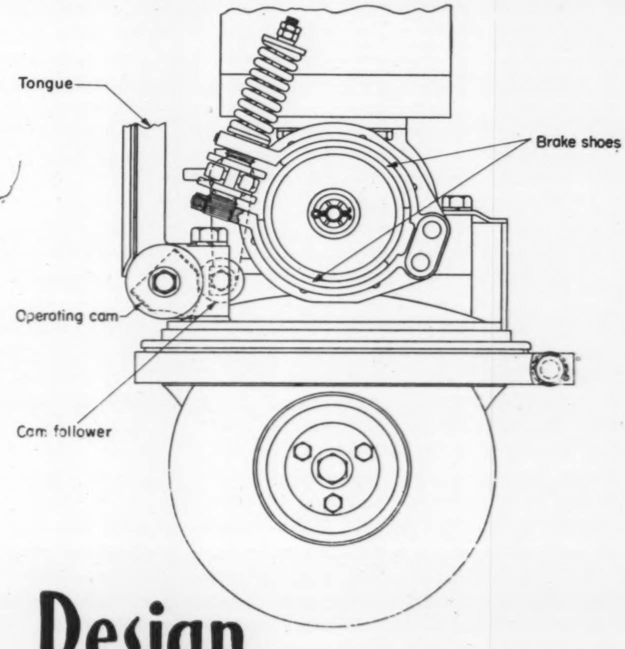

Guard plate
Horn button
Butterfly lever
Switch operating rod
Raise and lower buttons
Guide handle
Key-locked switch

**Control box at the end of the steering handle contains leaf-spring switches to operate the horn, hydraulic pump drive motor, traction motor and a solenoid valve for lowering the pallet forks. All controls are in series with a key-operated switch to prevent unauthorized operation of the truck.**

**Horn button is centered in a cutout in the butterfly switch which selects speed and direction of trav-**


Neg.
Pos.
F
F
Series field
R
R
Arm.
Traction resistor
$A_2$
$A_3$
Traction motor
Speed controller
Speed 1
Speed 2
Speed 3
Traction circuit
Tongue sw.
Forward coil
Reverse coil
For.
Rev.
Forward
Reverse
Key sw.
$A_2$
$A_3$
X indicates contacts closed
Lift circuit
Lift contacts
Pump motor
Series field
Arm.
Lift coil
Lift sw.
Solenoid valve coil
Lower sw.
Horn
Fuse
Horn
Horn sw.

al. Depressing one wing of the butterfly moves the switch operating rod to energize either forward or reverse contact coils and appropriately connect the series field of the traction motor. Degree of depression controls resistance in series with the motor and thereby speed. Tongue switch is controlled by steering handle or tongue position and automatically de-energizes the traction motor circuit when the handle is vertical or horizontal.


Tongue
Brake shoes
Operating cam
Cam follower

**Spring applied brake** is released by a cam and follower when the tongue is in travelling position. When the tongue is in either a vertical or horizontal position, brakes are applied by the spring. Brake is of the external-contracting type. Brake drum is mounted on a shaft in the reduction gear train between motor and drive wheel.

# Contemporary Design

## DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY *(Eleventh of a Series)*

# *A systematic approach to preparing*

By John D. Folley Jr. and James W. Altman
*Research Scientists, American Institute for Research, Pittsburgh*

MAINTENANCE procedures for electronic equipment specify the activities of the technician. Therefore, they indirectly determine the maintainability features that must be built into the prime equipment and any needed maintenance supports including training, personnel, etc.

Poorly "designed" maintenance procedures can offset the benefits of otherwise good design for maintainability. Delaying preparation of maintenance procedures until after the equipment is designed is likely to yield poor maintainability.

**Types of Procedures:** In general, procedures may describe every operation to be carried out, with no decisions required, or may include a number of choice points requiring decisions. The best compromise for a particular procedure is primarily a function of the task to be accomplished.

Routine replacement and repair procedures usually do not require decisions. Trouble-shooting procedures, however, usually must contain some decisions. Sometimes a set of general rules or principles is better than a fixed procedure.

**Procedures Needed:** Every maintenance operation should be specified in procedures prepared during system development. Procedures are required for checking, trouble shooting, adjusting, replacing, repairing and servicing. Recommendations given here apply at all maintenance levels—customer, field and factory—plus periodic maintenance. Checking and trouble-shooting procedures should be given most attention. These two functions of maintenance take a large part of technicians' time.

Specific recommendations are given in this article for checking and trouble-shooting procedures. The same general characteristics also apply to the other four functions just mentioned.

**General Recommendations:** Maintenance procedures should always be made as brief as possible without sacrificing necessary information. Procedures can sometimes be shortened by including certain steps that achieve the same result as several other steps. For example, instead of checking two independent outputs, check a third output that makes use of the first two. If it is in tolerance, the other two must also be in tolerance.

A procedure must give results that are as foolproof as possible. For example, if a properly performed check procedure yields an in-tolerance indication, the technician must be certain that the checked components are actually operating within tolerance. It is unlikely that many checks used in electronic maintenance give "certain" results, but the procedure should be such that out-of-tolerance conditions will almost always be found by the check procedures.

Procedures should always be in line with the skill and knowledge levels of the technicians who are to follow them. Concepts should be kept as simple as practical. Simplicity of concepts may be strongly influenced by equipment complexity if the technician must memorize any of them to perform the procedure. Procedures may sometimes be simplified by designing the test equipment to do some or all of the programming.

The number of decisions required should be minimized. A greater number of decisions means, in general, a more difficult task for the technician. Eliminating too many decisions, however, may make a procedure so long and time consuming that the inclusion of some decision making would be

# Maintenance Procedures

**The importance of good maintenance procedures and how they can influence design of electronic equipment are considered in this article. Recommendations are given for developing procedures for checking, trouble shooting, adjusting, replacing, repairing and servicing equipment.**

an improvement. Obviously, when the procedures are prepared, it must be decided which approach will be of greatest aid to the technician.

Decisions required in a procedure should also be made as simple as practicable. Decisions are simplified when the number of alternatives is minimized, and when the number of contingent conditions for selection of an alternative is reduced.

The amount and variety of test equipment required by a procedure should be kept to a minimum. A wide variety of test equipment requires a greater breadth of skill and knowledge on the part of the technician.

An exact step-by-step procedure is easiest to follow. New personnel will learn a procedure faster if the sequence is practically invariant than if it changes from one time to the next.

Procedures should not only specify how to start up equipment but how to shut it down. Otherwise the equipment may be left in a condition that is likely to cause accidents or shorten operating life of equipment.

Procedures should not require the technician to work near dangerous voltages or delicate components unless absolutely necessary.

Servicing procedures usually should not make it necessary to dismantle equipment. Most of the servicing should be performed through accesses.

**Trouble-Shooting Procedures:** It is especially important that systematic trouble-shooting procedures[1,2] be provided. Inefficient or even dangerous practices may be followed if efficient procedures are not provided. Systematic trouble shooting should proceed in three phases:

1. Routine check of system to identify or verify malfunction symptoms.
2. Symptom-pattern analysis to narrow the area

### Table 1—Typical Routine Check* for Systematic Trouble Shooting

- **1. Radar-Set Check**
  - 1.1 Power-Supply Checks
    - 1.1.1 DC Regulated Voltage, +300v
    - 1.1.2 DC Regulated Voltage, +150v
    - 1.1.3 DC Regulated Voltage, −150v
    - 1.1.4 Repeller Voltage
    - 1.1.5 AC Power Bus
    - 1.1.6 Relay Supply DC Voltage
  - 1.2 Transmitter-Output Checks
    - 1.2.1 Frequency
    - 1.2.2 Frequency Spectrum
    - 1.2.3 PRF
    - 1.2.4 Shape of Modulation Envelope
    - 1.2.5 Power Output
  - 1.3 Receiver Checks
    - 1.3.1 Sensitivity
    - 1.3.2 Output
    - 1.3.3 AFC
- **2. Search-Mode Operational Checks**
  - 2.1 Antenna Search Pattern
    - 2.1.1 Narrow Pattern (right and left)
    - 2.1.2 Wide Pattern (center)
    - 2.1.3 Antenna Spin Pattern
  - 2.2 Display Calibration
  - 2.3 Artificial Horizon
- **3. Manual Track Operational Checks**
  - 3.1 Antenna Control
  - 3.2 Manual Track Test
  - 3.3 Lock-on
    - 3.3.1 Sensitivity of Lock-On
    - 3.3.2 Display Function
- **4. Auto Track Operational Checks**
  - 4.1 Attack Phase Operational
  - 4.2 Rocketfire
  - 4.3 Pull-Out Warning
- **5. Miscellaneous Checks**
  - 5.1 Antenna Table Dither
  - 5.2 Radar Antijam Control Operation
  - 5.3 Pilot Scope Controls

*This is an outline of steps for a preflight check of fire-control system. It is presented to show how a routine check can be used in designing aids for systematic trouble shooting.

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[1] R. B. Miller, J. D. Folley Jr., and P. R. Smith—"Trouble Shooting in Electronics Equipment—A Proposed Method," American Institute for Research, Pittsburgh, March, 1953.

[2] R. B. Miller, J. D. Folley Jr., and P. R. Smith—"Systematic Trouble Shooting and the Half-Split Technique," *HRRC Technical Report* 53-21, Human Resources Research Center, San Antonio, Texas, July, 1953.

of malfunction.

3. Special checks to isolate the malfunction to a replaceable or repairable unit.

**Routine Checks:** These are checks that are regularly used to determine whether electronic equipment or a prescribed portion of equipment contains a malfunction. An example of a routine check is shown in Table 1.

Trouble shooting will usually begin with a routine check. It will tell the technician that a malfunction is present within the system and will provide information as to where within the system the malfunction is located. This information is in the form of a pattern of malfunction symptoms. Analysis of these symptoms by means of a list, such as shown in Table 2, may eliminate the need for certain special checks.

**Symptom-Pattern Analysis:** One way to help the technician analyze symptom patterns is to provide him with special system diagrams. These diagrams would indicate which components affect each system output for each step of the routine check procedure. For each step, the components that have come into operation and have gone out of operation since the previous step should be indicated. From this information the technician can "figure out" which components could be causing a certain pattern of symptoms. However, it is usually better to tell the technician what components could be causing the symptoms. This can be done by providing him with a diagram for each symptom pattern, showing the data flow among possible malfunctioning components and/or a list of possible malfunctioning components for each symptom pattern.

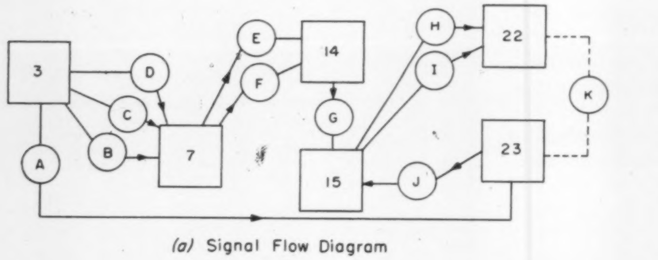
The number of possible patterns observable from $n$ mutually exclusive symptoms is $2^n - 1$, and becomes quite large even with a moderate number of possible symptoms. Thus for 10 symptoms there are 1023 patterns. Providing analyses for this many patterns is impractical, and they will be of little use in the field.

There are two major ways of reducing the number of different patterns that must be analyzed. Both involve working with groups of symptoms and both will not, usually, make full use of the information available from the routine check.

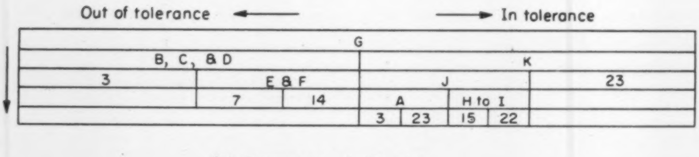
The first way is to combine a number of individual symptoms into a single group symptom. The group symptom is considered to have occurred if any of the individual symptoms in the group occurs. A diagram, Fig. 1*a*, is then prepared for each pattern of group symptoms showing the data flow among all of the components in which a malfunction could cause the observed pattern of group symptoms. No information available from the routine check is lost by this method when the same components could cause all of the individual symptoms in a particular group.

The second way to reduce the number of symptom patterns is to divide the individual symptoms into groups and then prepare a diagram only for each within-group symptom pattern. Thus, if nine symptoms were divided into three equal groups as done in Table 3, the designer would prepare $2^3 + 2^3 + 2^3 - 3$ or 21 different diagrams instead of the $2^9$-1 or 511 diagrams for all possible patterns for individual symptoms. No information available from the routine check is lost by this method when no component could cause symptoms in more than one group.

**Special Checks:** The technician should be provided with aid in choosing the best sequence of special checks to use after the symptom pattern has been analyzed. Usually the sequence of checks should be flexible, with the exact sequence de-



(a) Signal Flow Diagram



(b) Sequence of Checks

Fig. 1—In *a* is a signal flow diagram in an electronic fire-control system for trouble shooting symptom pattern condition of 2.1 = X, 2.2 = O, and 2.3 = O in Table 2. The squares are customer-replaceable units in the equipment and the circles are test points. A chart for a flexible yet efficient sequence of checks for this symptom pattern is shown in *b*. Checks are made starting with the top line first. If all are *in-tolerance,* checks are made in box immediately below and to the right. If any signal or other condition is *out-of-tolerance,* checks are made immediately below and to the left.

pending upon where malfunction symptoms are observed. There is one exception. An inflexible order of checks can be specified where the time required for a particular sequence is likely to be small. This is usually the case only in trouble shooting to parts after a malfunction has been isolated to a particular stage of equipment.

Prescribe a sequence of checks such that the malfunction is first isolated to a single series chain. The best check to make first in isolating the trouble to a particular chain is at the terminal output of the chain where the probability of observing the malfunction in that check divided by the time required to make the check is a maximum. Three considerations are relevant here: (1) the "series chain" may have a number of branches contributing to its final output; (2) the probability of the malfunction being in a given chain may be determined from data on the frequency of malfunctions, or may be based simply upon the number of components in the chain; (3) the time required to perform certain checks may have to be estimated.

### Table 2—Typical Malfunction Symptom-Pattern Chart*

| Symptom Pattern | | | Trouble-Shooting Directions |
|---|---|---|---|
| 1.1 | 1.2 | 1.3 | |
| X | O | O | Do not run test 1.2 and 1.3 until power supply is adjusted correctly or replaced |
| O | X | O | Use signal flow diagram 1*a* for trouble shooting |
| O | O | X | Use signal flow diagram 1*b* for trouble shooting |
| O | X | X | Use signal flow diagram 1*c* for trouble shooting |
| 2.1 | 2.2 | 2.3 | |
| X | O | O | Use signal flow diagram 2*a* for trouble shooting |
| O | X | O | Use signal flow diagram 2*b* for trouble shooting |
| O | O | X | Use signal flow diagram 2*c* for trouble shooting |
| X | X | O | Replace master controller (CRU† 7) |
| O | X | X | Use signal flow diagram 2*d* for trouble shooting |
| X | O | X | Replace master controller (CRU 7) |
| X | X | X | Replace master controller (CRU 7) |
| 3.1 | 3.2 | 3.3 | |
| X | O | O | Use signal flow diagram 3*a* for trouble shooting |
| O | O | X | Use signal flow diagram 3*b* for trouble shooting |
| X | X | O | Replace master controller (CRU 7) |
| O | X | X | Use signal flow diagram 3*c* for trouble shooting |
| X | O | X | Use signal flow diagram 3*d* for trouble shooting |
| X | X | X | Use signal flow diagram 3*e* for trouble shooting |
| 4.1 | 4.2 | 4.3 | |
| X | O | O | Use signal flow diagram 4*a* for trouble shooting |
| O | X | O | Use signal flow diagram 4*b* for trouble shooting |
| O | O | X | Use signal flow diagram 4*c* for trouble shooting |
| X | O | X | Use signal flow diagram 4*d* for trouble shooting |
| O | X | X | Replace master computer "B" (CRU 13) |
| X | X | X | Use signal flow diagram 4*e* for trouble shooting |
| 5.1 | 5.2 | 5.3 | |
| X | O | O | Use signal flow diagram 5*a* for trouble shooting |
| O | X | O | Use signal flow diagram 5*b* for trouble shooting |
| O | O | X | Use signal flow diagram 5*c* for trouble shooting |
| X | X | X | Check for voltage at main power bus<br>If this checks OK replace pilots control box (CRU 3). |

*Symptom patterns obtainable from preflight check obtainable in Table 1 for a fire-control system. A malfunction symptom observed is designated by X and an in-tolerance indication by O.
†CRU means a customer-replaceable unit.

### Table 3—Group-Step Symptom Pattern Chart*

| Routine Check (Group) | (Step) | Symptom Pattern for Each Step | Symptom Pattern for Each Group |
|---|---|---|---|
| A | 1 | X | X |
| | 2 | X | |
| | 3 | O | |
| B | 4 | O | O |
| | 5 | O | |
| | 6 | O | |
| C | 7 | O | X |
| | 8 | O | |
| | 9 | X | |

*Absence of a symptom is indicated by O and its presence by X. The total number of possible step patterns is 511. The total number of possible group patterns is 7.

Once a malfunction has been isolated to a single chain, the best procedure is to check at the point in the chain where the probability of observing a malfunction is closest to one-half[2]. The checking sequence is affected, however, by the time required to make the various checks. It may be desirable to make the least time-consuming checks first even though they may not adhere to the principle of one-half probability just outlined. It may also be desirable to delay checks of components in feedback loops if the time required to break the loop for checking is appreciable.

Provide the technician with appropriate signal flow diagrams, Fig. 1*a, and* a table or chart for each symptom pattern giving the most efficient sequence of checks. The chart in Fig. 1*b* illustrates a flexible order of checks that depends upon whether or not an out-of-tolerance indication is obtained at each point. The first check that should be made if a given symptom pattern is observed is represented by *G*. The letters *B*, *C*, *D* or *K* represent alternative checks following *G*, and so on. Choose the next alternative to the *left* following an out-of-tolerance indication, and the one to the *right* following an in-tolerance indication.

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| Units, Assemblies and Subassemblies | June 28, 1956 |
| Covers and Cases | July 12, 1956 |
| Wiring, Cables and Connectors | July 26, 1956 |
| Maintenance Accesses | Aug. 9, 1956 |
| Test Points | Sept. 6, 1956 |
| Controls | Sept. 20, 1956 |
| Displays | Oct. 4, 1956 |
| Equipment Installation | Oct. 18, 1956 |
| Maintenance Auxiliaries | Nov. 15, 1956 |

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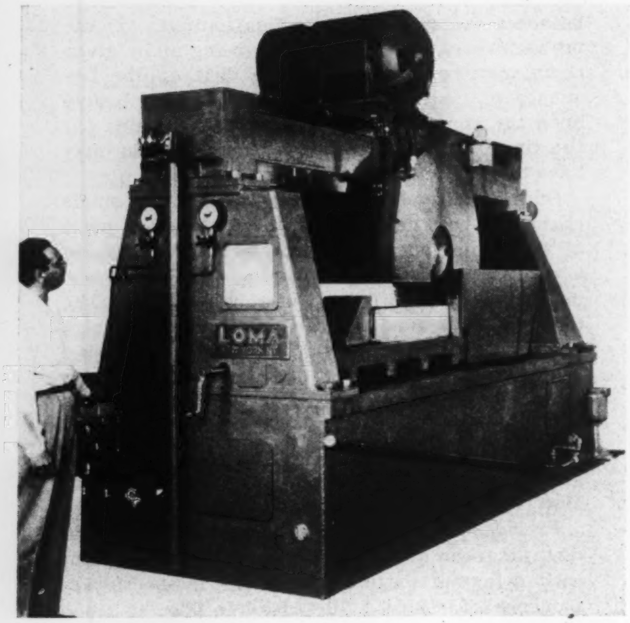
". . . it would seem to me to be a relatively safe prediction that in 20 years—barring a world catastrophe—we will need twice as large a fraction of our working force engaged in science, engineering, and medicine as we have today. Maybe it will be 30 years. But the trend is in this direction, and the task will be a gigantic one. We had better explore the possibilities . . ."—DR. LEE A. DUBRIDGE, *California Institute of Technology.*

## Overhead Carriage Protects Saw



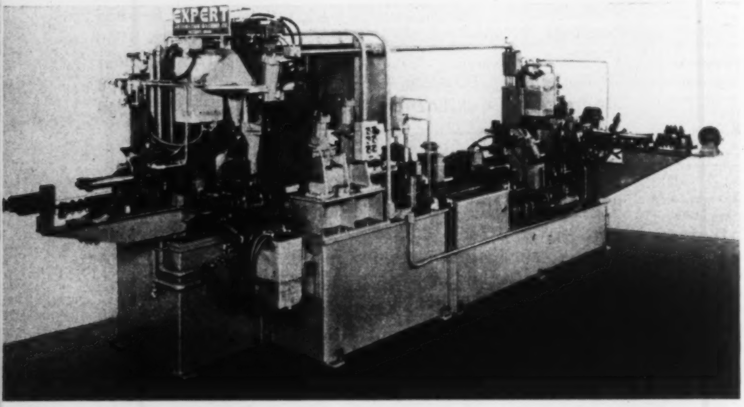
ALL moving parts of a recently announced ingot saw are mounted on an overhead carriage to provide maximum protection for all moving parts such as motor, carriage, blade drive and feed mechanism. This design approach protects all such parts from damage from lubricants and chips. Protection for the operator is also provided in this product of Loma Machine Mfg. Co. Inc. by placing remote controls for all adjustments and operations on the outer end of the machine. This places a wide cross-beam support between the saw and the operator. A window in the support allows the operator to observe the cutting process.

# Contemporary Design

## Machine Automatically Makes Wire Baskets

ALL operations necessary to produce a finished wire basket from bulk wire are performed by a new machine which performs a variety of operations. A product of Expert Automation Machine Co., the machine draws five parallel longitudinal wires and cross wires from stationary reels. Wires are straightened before being resistance welded together to form a flat mesh strip from which the rectangular baskets are formed.

As the longitudinal wires are fed in, cross wires are fed at right angles. Cross wires are then resistance welded to the longitudinal wires. During the time they are being welded to the longitudinal wires, the cross wires are sheared from the feed reels. The wire pattern is then advanced the length required for one basket and this length is sheared off. Corners of the cut length of mesh are then cut out to form the basket pattern. Cross wires are then trimmed flush with the outside longitudinal wires. This prepared pattern is then folded and welded into a 4¼ by 7¼ by 4-in. deep basket.



### *A rapid method for developing*

# Cam Profiles

### *having desired acceleration characteristics*

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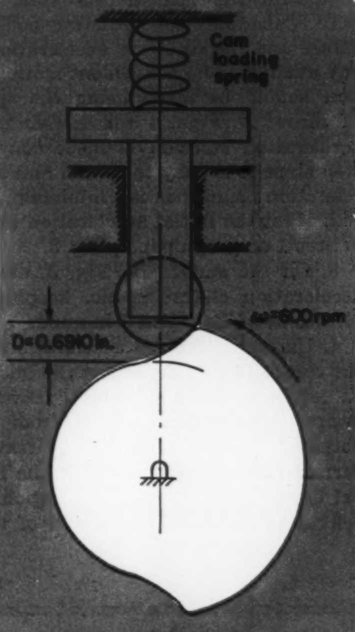

Fig. 1 — Typical spring-loaded cam mechanism.

THE THEORY of finite differenes was suggested in a recent article[1] as a simple and flexible arithmetical method for cam design. With this method, any desired and feasible acceleration characteristic can be obtained by systematically adjusting the follower-body displacement points in a sequential manner to obtain the desired acceleration factor variation. This might be thought of as a whittling process, and the speed of adjustment depends on foresight and ingenuity.

This article presents a method for arriving at the desired acceleration characteristic in only two displacement-adjustment traverses. In effect, the suggested method introduces a positive controlling factor to the whittling process and removes the ingenuity requirement.

**Basic Relations:** In the movement of a body from one position to another, acceleration, velocity and displacement variations are compatible with each other. For instance, during a given period of time the change in velocity, $\Delta v$, must equal the area under the acceleration-time plot:

$$v_2 - v_1 = \Delta v = \int_{t_1}^{t_2} a\, dt \qquad (1)$$

Also, the change in displacement, $\Delta s$, during the same interval must equal the area under the velocity-time plot:

$$s_2 - s_1 = \Delta s = \int_{t_1}^{t_2} v\, dt \qquad (2)$$

Combining Equations 1 and 2 results in the following relationship between the change in displacement, initial velocity, and area under the acceleration-time plot:

$$s_2 - s_1 = \Delta s = \int_{t_1}^{t_2} \left( v_1 + \int_{t_1}^{t} a\, dt \right) dt \qquad (3)$$

**Development of Desired Acceleration:** A common problem is the development of a profile which has special acceleration characteristic and, yet, imparts to the follower a specified amount of throw. It is the combination of these necessarily compatible requirements which makes the uncontrolled, successive-traverse method sometimes difficult. Hence, the following method has been developed as a rapid process for arriving at a desired acceleration characteristic. The outlined method assumes that the follower body starts and ends its motion in a state of zero velocity (dwell-rise-dwell). Figs.

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[1] References are tabulated at end of article.

1-4, which contain the details of a numerical example to be presented later, are also referenced in the outlined method at this point. The steps are:

1. Calculate the follower-body displacement values and the resulting acceleration factors, using any available and convenient motion. This calculation should be made using the specified amount of throw, *D*, Figs. 1 and 4. Generally a constant-acceleration solution is most convenient for this step since it is easy to obtain and the resulting acceleration magnitude is a minimum.
2. Plot the initial acceleration factors calculated in Step 1 on graph paper, Fig. 3.
3. On the same plot, Fig. 3, sketch the *desired* acceleration characteristic, keeping the area implications of Equation 3 in mind.
4. Using the desired acceleration factor curve as the controlling guide, adjust the initial displacement values in a single sequential traverse so that the desired acceleration factors from the sketch are obtained at each point. This traverse should be carried through, and possibly one cam-angle interval beyond, the development region. The large acceleration resulting at the end of the traverse but outside of the development region will not matter, since it will be eliminated by the next step. Step 4 is guided by the desired acceleration characteristic sketched in Fig. 3 and the single traverse is shown in the third column of Fig. 2.
5. The adjusted displacement values from Step 4 will generally differ appreciably from the initial values calculated in Step 1. In fact, unless the designer is unusually fortunate, the throw after Step 4 will differ appreciably from the desired throw, *D*, by an amount which will be called ***h***. For Step 5, *change* each of the adjusted displacements existing after Step 4 by an amount equal to $h/(D+h)$ times the adjusted displacement. Generally this *change* can be computed accurately enough on a slide rule. Incidentally, *h* will be considered as positive if the throw after Step 4 is greater than the desired throw, *D*, and negative if that throw is less than *D*. Changing each of the displacements by this factor will result in the correct total throw and the desired acceleration characteristic will be retained. In effect, Step 5 proportionately compresses (or expands) the displacements to give the correct throw without changing

**Fig. 2—Calculation sheet for developing a cam profile having a desired acceleration characteristic.**

| Cam Angle $\theta$ (deg) | Displacements, $s$ (inches ×$10^4$) | | | | Acceleration Factors ($s_1+s_2-2s_0$) | | | |
|---|---|---|---|---|---|---|---|---|
| | Initial (from constant-accel. solution) (Step 1) | Adjustments dictated by desired accel. sketch of Fig. 3 (Step 4) | Change for obtaining correct throw (Step 5) | Total (Step 8) | Initial (Step 1) | Corrected for desired shape (Step 4) | Corrected for correct throw specification (Step 6) | Calculated from total displacements (check) (Step 8) |
| 0 | 0 | — | 0 | 0 | ~~+12~~ | ~~+4~~ | | +4 |
| 1 | 12 | -8 | 0 | 4 | ~~+24~~ | ~~+40~~ ~~+17~~ | +16 | +16 |
| 2 | 48 | -23 | -1 | 24 | ~~+24~~ | ~~+16~~ ~~+62~~ ~~+24~~ | ~~+26~~ +22 | +22 |
| 3 | 108 | -38 | -4 | 66 | ~~+23~~ | ~~0~~ ~~+76~~ ~~+28~~ | ~~+27~~ ~~+35~~ +27 | +27 |
| 4 | 191 | -48 | -8 | 135 | ~~+25~~ | ~~-13~~ ~~+83~~ ~~+30~~ | ~~+26~~ ~~+42~~ +28 | +28 |
| 5 | 299 | -53 | -14 | 232 | ~~+23~~ | ~~-25~~ ~~+81~~ ~~+32~~ | ~~+24~~ ~~+52~~ +31 | +31 |
| 6 | 430 | -49 | -21 | 360 | ~~+25~~ | ~~-28~~ ~~+70~~ ~~+32~~ | ~~+18~~ ~~+60~~ +29 | +29 |
| 7 | 586 | -38 | -31 | 517 | ~~+23~~ | ~~-26~~ ~~+50~~ ~~+32~~ | ~~+11~~ ~~+73~~ +31 | +31 |
| 8 | 765 | -18 | -42 | 705 | ~~+24~~ | ~~-14~~ ~~+22~~ ~~+31~~ | ~~0~~ ~~+84~~ +30 | +30 |
| 9 | 968 | +9 | -54 | 923 | ~~+25~~ | ~~+7~~ ~~-11~~ ~~+30~~ | ~~-12~~ ~~+96~~ +27 | +27 |
| 10 | 1196 | +41 | -69 | 1168 | ~~+23~~ | ~~+32~~ ~~-50~~ ~~+28~~ | ~~-26~~ ~~+112~~ +27 | +27 |
| 11 | 1447 | +78 | -85 | 1440 | ~~+24~~ | ~~+65~~ ~~-91~~ ~~+25~~ | ~~-44~~ ~~+126~~ +23 | +23 |
| 12 | 1722 | +116 | -103 | 1735 | ~~+23~~ | ~~+101~~ ~~-131~~ ~~+22~~ | ~~-63~~ ~~+143~~ +22 | +22 |
| 13 | 2020 | +153 | -121 | 2052 | ~~+23~~ | ~~+141~~ ~~-165~~ ~~+19~~ | ~~-84~~ ~~+158~~ +17 | +17 |
| 14 | 2343 | +184 | -141 | 2386 | ~~+24~~ | ~~+177~~ ~~-191~~ ~~+15~~ | ~~-106~~ ~~+176~~ +15 | +15 |
| 15 | 2690 | +206 | -161 | 2735 | ~~+23~~ | ~~+207~~ ~~-205~~ ~~+10~~ | ~~-131~~ ~~+191~~ +8 | +8 |
| 16 | 3060 | +215 | -183 | 3092 | ~~+25~~ | ~~+231~~ ~~-199~~ ~~+5~~ | ~~-156~~ ~~+210~~ +6 | +6 |
| 17 | 3455 | +204 | -204 | 3455 | ~~0~~ | ~~+215~~ ~~-193~~ ~~0~~ | ~~-183~~ ~~+225~~ 0 | 0 |
| 18 | 3850 | +193 | -225 | 3818 | | | | |

the general shape of the desired acceleration characteristic. The displacement corrections are illustrated in the fourth column of Fig. 2.

6. In a single sequential traverse, correct the acceleration factors to agree with the displacement corrections just made in Step 5.

7. Plot the acceleration factors from Step 6 on the same graph, Fig. 3. The acceleration factors from Step 6 should be very similar to the desired acceleration variation sketch.

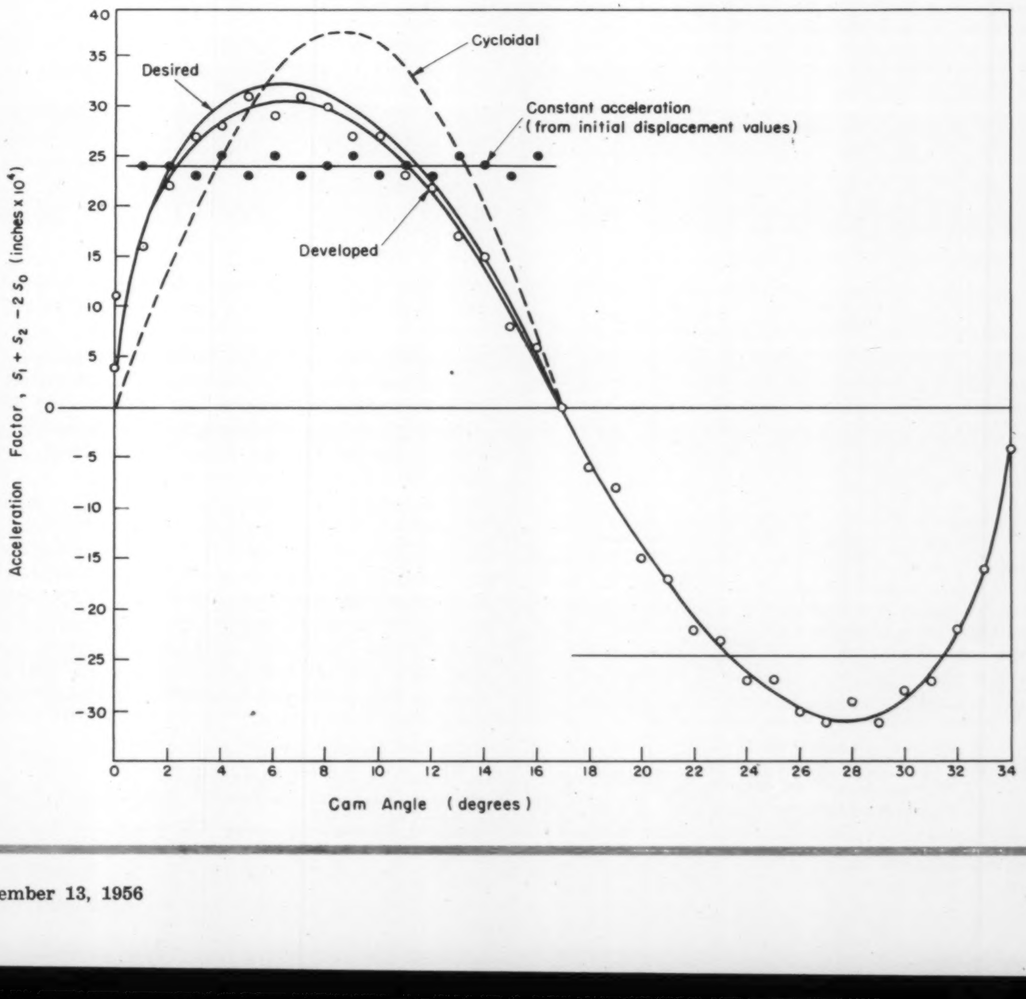
8. Calculate the total displacements at each point merely by summing the initial displacement with the corrections made in Steps 4 and 5. Using these total displacement values, calculate the acceleration factors at each point. If no mistakes have been made in the development process, these acceleration factors should agree exactly with the acceleration factors obtained at the end of Step 6. Step 8 merely serves as a check on the accuracy.

In the method just outlined, it was assumed that the follower body started from rest and ended at rest. The motion was developed to satisfy a specified throw and a desired acceleration characteristic.

Other types of problems can be attacked in a similar manner. For instance, if the initial and final velocities were specified as values other than zero, and if a particular acceleration characteristic were desired, then a very similar method can be used. The desired acceleration sketch would be made on the initial acceleration plot as before, but Equation 1 would then be kept in mind for its area implications instead of Equation 3 as before. Also, the expansion or compression of displacements corresponding to Step 5 would be made using a velocity factor deviation proportionality term instead of the displacement deviation proportionality term, $h/(D + h)$.

**Example:** Suppose a cam mechanism is to drive a follower body from one position to another during 34 degrees rotation of the cam. Assume that the cam will rotate at a constant velocity of 600 rpm and that the follower body is initially and finally in a state of rest. The mechanism is to be spring loaded as illustrated in Fig. 1 and the total throw is to be 0.6910-in. Assume that the follower body

Fig. 3—Comparative plot of acceleration curves.



displacement values can be held to a point-to-point variation of 0.0003-in. due to machining errors on the cam surface.

A constant-acceleration solution to the problem gives a maximum acceleration of 31,000 in. per sec$^2$. A cam angle interval of $\Delta\theta = 1$ deg gives an average acceleration deviation[1] due to machining tolerances of $a_t = \pm 144 \, (\omega/\Delta\theta)^2 \, t = \pm 144 \, (600/1)^2 \, (0.0003) = \pm$ 15,6.00 in. per sec$^2$. As- $(600/1)^2 \, (0.0003) = \pm$ 15,600 in. per sec$^2$. Asable value which the designer feels can exist.

Assuming that the motion will be entirely symmetrical, the development needs only to be carried out for 17 deg of cam rotation, since the remaining 17 deg will be similar. The initial follower-body displacement values are calculated for a constant acceleration type of solution. These values and the calculated acceleration factors are given in Fig. 2 (Step 1 columns) and Figs. 3 and 4.

The desired acceleration factor is sketched on Fig. 3. The desired variation differs appreciably from both the constant-acceleration solution and the cycloidal solution which is also outlined on Fig. 3. The desired variation is smooth, low in magnitude and displaced in a sidewise direction from the cycloidal variation.

It is well known that acceleration smoothness is a highly desirable characteristic from a vibrational standpoint. Likewise the low magnitude is highly desirable from a follower contact force consideration. The sidewise displacement of the acceleration characteristic is selected for the following reason:

The maximum acceleration for the desired characteristic occurs early in the follower-body displacement motion. Hence, if a proper gradient is chosen for the cam loading spring, the maximum acceleration will occur at a point where the spring deformation and, hence, the spring force is low in magnitude. Therefore, the maximum cam-to-follower contact force will be lower than if the maximum acceleration occurred at a point where the spring was compressed more. In the decelerating region, a sidewise acceleration displacement is also desirable since then the maximum deceleration occurs later in the stroke, at a point closer to where the maximum spring force exists. Also, a smoother cam-to-follower contact force variation results from the desired acceleration variation sketched in Fig. 3. Inclusion of the spring force variation accounts for this result, as illustrated in a previous article.[2]

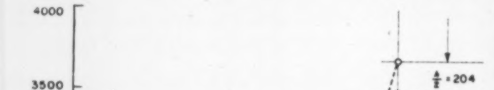


Fig. 4 — Comparative plot of displacement curves.

The next step involves adjusting the follower body displacements in order to obtain the acceleration-factor variation corresponding to the desired curve sketched in Fig. 3. In Fig. 2 the displacement values are adjusted in sequential order from 0 to 18 deg (Step 4), the adjustment being made according to the demands of the desired acceleration factor of the previous point. For instance, the 1-deg displacement value is adjusted by $-8$ since this adjustment changes the acceleration factor of the 0-deg point to the desired value from the sketched curve of $+4$. Likewise, the 2-deg displacement value is adjusted by $-23$ since this adjustment changes the acceleration factor of the 1-deg point to the desired value from the sketched curve of $+17$. The displacement adjustments are made in that manner down to the 18-deg point.

At the end of the traverse, it is noticed that the actual displacement of the 17-deg point is now $0.3455 + 0.0204 = 0.3659$-in. instead of the desired throw of 0.3455-in. at the halfway point. Hence, $D/2 = 0.3455$ and the displacement deviation, $h/2 = 0.0204$-in. Therefore, each displacement point will be *changed* by a factor equal to $0.0204/(0.3455 + 0.0204) = 204/3659$. These *changes,* calculated on a slide rule, are given in Fig. 2 (Step 5).

The next step is to correct the acceleration factors then existing as the last values after Step 4 according to the displacement adjustments just made. Hence, for the 2-deg displacement adjustment of $-1$, the acceleration factors of the 1-deg and 3-deg points change by $-1$, and the acceleration factor of the 2-deg point changes by $-2\,(-1) = 2$. The acceleration factors are corrected by considering the displacement adjustments (Step 5 column) in a sequential manner, starting from the 0-deg to the 18-deg points. The final acceleration factors then exist as the last values in Step 6, and they are plotted as the developed characteristic in Fig. 3. It can be seen from Fig. 3 that the developed characteristic agrees very well in shape with the desired characteristic sketch.

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**Servomotors**
**Preamplifiers**
**Transducers**
**Feedback Elements**

# Hydraulic Servo Components—2

## . . . their effect on system performance

By J. M. Nightingale
*Manchester, England*

AUTOMATIC-control or servo systems are only as effective as the various components making up the system. Nomenclature and details of basic system components, Fig. 12, are covered in this article. Input elements, error detectors, valve amplifiers and power supplies were covered in Part 1.

**Servomotors:** Hydraulic servomotors are substantially pumps in reverse. In fact most hydraulic pumps could, with a few modifications to valve timing and so on, be run as motors. Where a linear output displacement is required, either a rotary motor driving through worm gearing, or a linear displacement motor—a piston-type hydraulic cylinder—can be used. Cylinders are usually of the double-acting variety, Fig. 13. Neglecting leakage and compressibility, flow characteristic for this cylinder is

$$Q = A\left(\frac{dy}{dt}\right) \tag{8}$$

or in terms of transformed quantities

$$y(s) = \left(\frac{1}{As}\right)Q(s) \tag{9}$$

where $Q$ = flow into cylinder, $y$ = piston displacement, $A$ = piston area, and $s$ = Laplace operator.

For a rotary motor, similarly

$$Q = 2\pi V_m \left(\frac{d\theta}{dt}\right) \tag{10}$$

or by Laplace transformation

$$\theta(s) = \frac{1}{2\pi V_m} Q(s) \tag{11}$$

where $\theta$ = angular displacement of motor shaft and $v_m$ = volumetric displacement of motor per revolution.

**Preamplifiers and Transducers:** In many medium and high-power hydraulic servos, power needed to displace the controlling element of the main amplifier is very considerable when compared with the power in the error signal. This is particularly

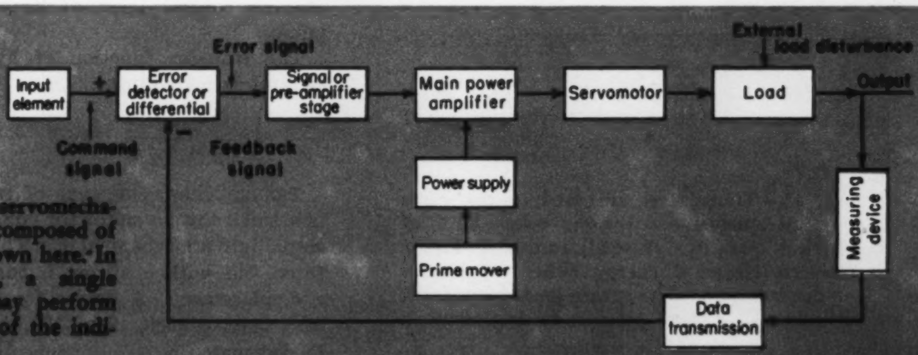

Error signal
External load disturbance
Input element
+
Error detector or differential
Signal or pre-amplifier stage
Main power amplifier
Servomotor
Load
Output
Command signal
−
Feedback signal
Power supply
Prime mover
Measuring device
Data transmission

Fig. 12 — A servomechanism is usually composed of the elements shown here. In some instances, a single physical unit may perform more than one of the indicated functions.

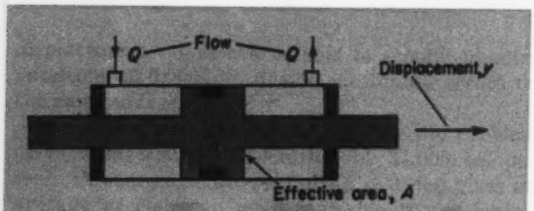


Fig. 13—Hydraulic servomotors for linear output displacement are usually of the double-acting cylinder type shown here.

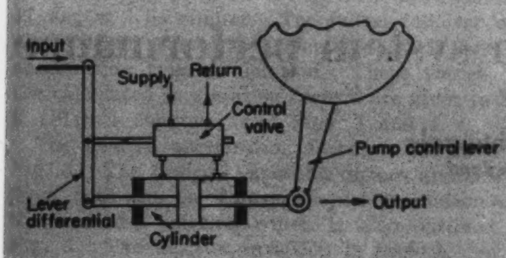


Fig. 14—One type of hydraulic preamplifier is the hydraulic relay consisting of a small control valve and hydraulic cylinder. The hydraulic relay shown here is a closed-loop device controlling a variable-displacement pump.

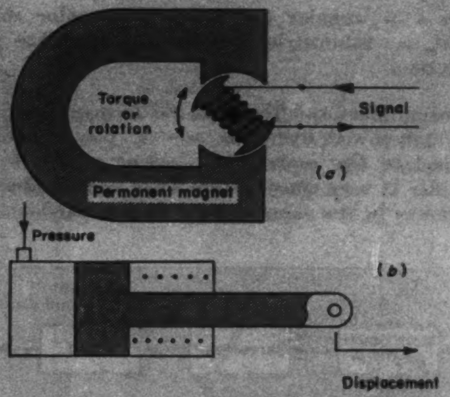
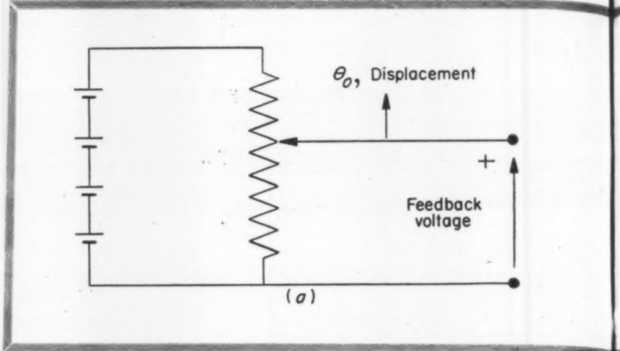


Fig. 15—Transducers are used to convert a physical quantity into some other kind of physical quantity. A small torque motor, *a*, converts electrical energy either to a force or displacement. The spring-loaded hydraulic cylinder, *b*, converts pressure to displacement.



so when the command signal is a low power electrical signal. Therefore, in the low-power end of the servo there is usually a sequence of elements for operating on the error signal. These include preamplifiers for boosting the power to a sufficiently high level and transducers for changing the physical nature of the signal without power amplification, for instance, from a voltage to a displacement and so on. There may also be frequency-sensitive networks for improving the performance of the system.

ELECTRONIC PREAMPLIFIERS: So far as the operating range of most mechanical servos is concerned, electronic preamplifiers have no lags. Therefore,

$$e_o = Ke_i \tag{12}$$

where $e_i$ = input voltage, $e_o$ = output voltage, and $K$ = gain constant.

HYDRAULIC PREAMPLIFIERS: These are pilot valves for operating main valves. They are open-loop amplifiers, often flapper-nozzle valves. They have a transfer function which usually approximates

$$\frac{x}{F}(s) = \frac{K}{1 + Ts} \tag{13}$$

where $x$ = main valve displacement, $F$ = input force, $K$ = gain constant and $T$ = time constant.

HYDRAULIC RELAYS are another type of preamplifier consisting of a small control valve and motor. Usually, they are closed-loop device in themselves, Fig. 14. Here a hydraulic relay is used to operate the control lever of a variable-displacement pump.

The transfer function of hydraulic relays can be approximated by

$$\frac{x_o}{x_i}(s) = \frac{K}{1 + Ts} \tag{14}$$

TRANSDUCERS: One type of transducer, Fig. 15*a*, is a small torque motor for converting an electrical signal into a mechanical one. The output is usually a force, but with a spring it can be converted into a displacement. A device for converting pressure into displacement, Fig. 15*b*, is merely a spring-loaded piston.

It is usually assumed that transducers are without time lags. This is a fair assumption provided

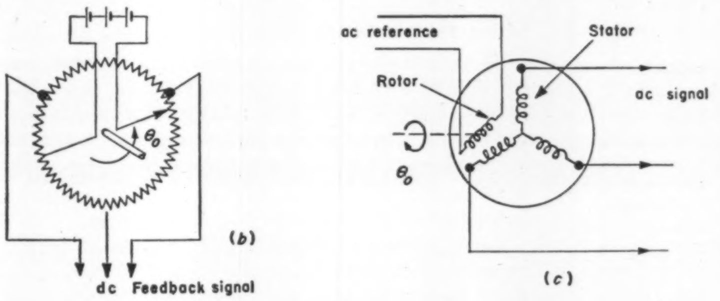


Fig. 16—Measuring devices are used to measure system output. Often they will also convert displacement to a proportional electrical quantity. A potentiometer *a*, dc synchro *b*, and ac synchro *c* are typical of such devices.

the low power side of the servo is only lightly loaded.

**Feedback Elements:** Measuring devices and data-transmission systems are the usually encountered feedback elements. Measuring devices are used to obtain a measure of the output for feedback. The function of data-transmission systems is to transmit the output signal back to the differential if the two are remote. Occasionally they are used to transmit other signals.

MEASURING DEVICES must be linear and accurate, must not load the output motor and must give signals which can be easily transmitted. Some typical measuring devices, Fig. 16, convert output displacement to a varying voltage or voltages. A number of widely used measuring devices are variable resistors, capacitors or inductors.

DATA TRANSMISSION SYSTEMS may be rods, cables or shafts when the output and input signals are both displacement. Although levers, pulleys and gears can be used to change direction in these mechanical systems, the degree of remoteness of input and output is limited. Some other disadvantages are that operating forces can be high due to inertia and friction. These tend to aggravate inaccuracies due to backlash and flexure. Advantages are that no separable output measuring device is needed. Also mechanical systems can be strong and reliable.

Electrical data transmission systems have obvious advantages where remote control is desired. A big advantage is that only a light load is added to the output motor. In a remote position indicating system which uses a dc synchro, Fig. 17*a*, output position is taken up by a permanent magnet

**Nomenclature**

$A$ = Area, sq in.
$e_i$ = Input voltage
$e_o$ = Output voltage
$F$ = Input force, lb
$K$ = Gain constant
$Q$ = Flow, cu in. per sec
$s$ = Laplace operator
$T$ = Time constant
$V_m$ = Volumetric displacement of motor, cu in. per rev
$x$ = Valve displacement, in.
$x_i$ = Input displacement, in.
$x_o$ = Output displacement, in.
$y$ = Piston displacement, in.
$\theta$ = Angular displacement of motor shaft

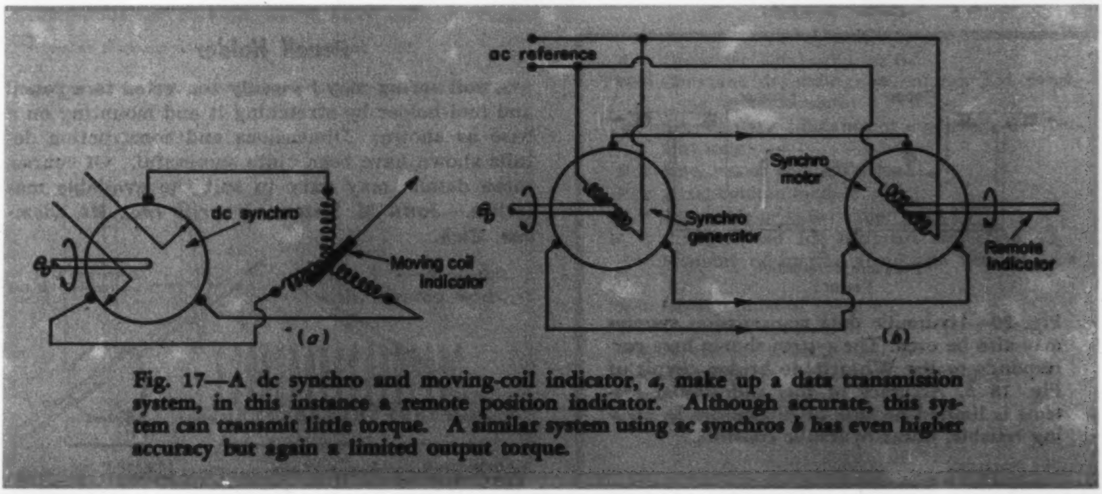


Fig. 17—A dc synchro and moving-coil indicator, *a*, make up a data transmission system, in this instance a remote position indicator. Although accurate, this system can transmit little torque. A similar system using ac synchros *b* has even higher accuracy but again a limited output torque.

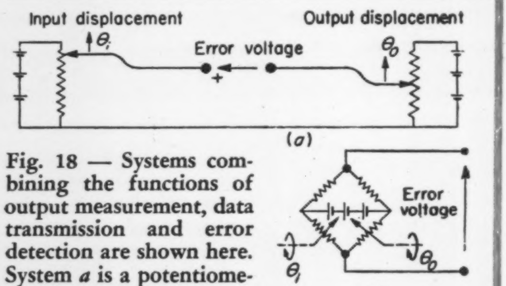

Input displacement
Output displacement
$\theta_i$
Error voltage
$\theta_o$
(a)
Error voltage
$\theta_i$
$\theta_o$
(b)

Fig. 18 — Systems combining the functions of output measurement, data transmission and error detection are shown here. System *a* is a potentiometer system. System *b* utilizes the Wheatstone bridge principle.

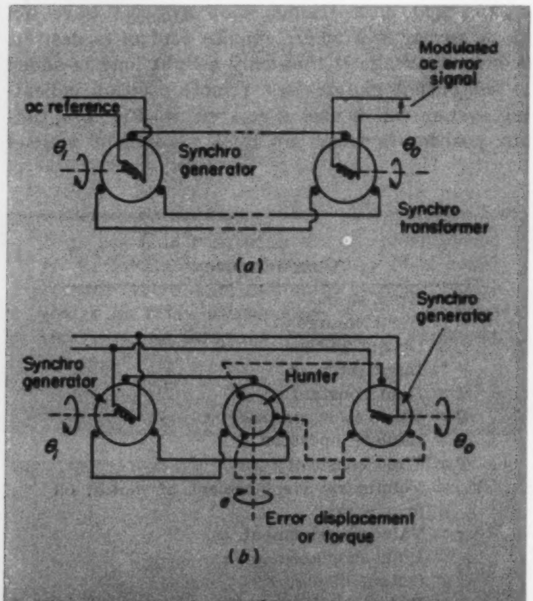

Modulated ac error signal
ac reference
$\theta_i$
Synchro generator
$\theta_o$
Synchro transformer
(a)
Synchro generator
Synchro generator
Hunter
$\theta_i$
$\theta_o$
e
Error displacement or torque
(b)

Fig. 19—Functions of output measurement, data transmission and error detection are combined in these systems using ac synchros.

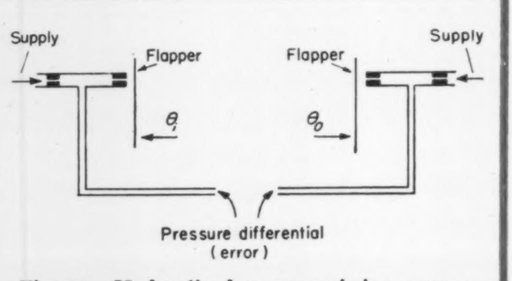

Supply
Flapper
Flapper
Supply
$\theta_i$
$\theta_o$
Pressure differential
(error)

Fig. 20—Hydraulic data transmission systems may also be used. The system shown here corresponds to the Wheatstone bridge circuit of Fig. 18 *b*. Accuracy of this and similar systems is limited because of difficulties in making reliable, linear hydraulic resistors.

which rotates in the field set up by the synchro. This system is accurate to within ±2 degrees, but no appreciable torque can be exerted. Thus its practical use is limited to remote instrumentation, for instance, in a manual-control system. A similar system employing two ac synchros in a generator-motor setup, Fig. 17*b*, has accuracy of ±¼ degree, but again only limited torque is available.

Some systems combine the functions of output measurement, data transmission and error detecting. Two examples are the potentiometer and bridge systems shown in Fig. 18.

Systems employing ac synchros are popular. These can be merely outlined here. A synchro generator and a control transformer give a modulated ac error signal whose amplitude depends on sin $(\theta_i - \theta_o)$, Fig. 19. The system shown in Fig. 19*b* has two generators and a differential motor, called a *hunter*. If the hunter is only lightly loaded it gives a displacement proportional to the error. If the motor shaft is constrained, however, it exerts a torque proportional to the error.

Sometimes hydraulic data transmission systems are used. For instance the system shown in Fig. 20 corresponds to the bridge shown in Fig. 18*b*. The system gives a differential pressure which is proportional to the error. Such systems are of limited accuracy because of the difficulty of making reliable linear hydraulic resistors.

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This article is the seventh in a co-ordinated group by J. M. Nightingale on servo systems. The previous article and the issues of MACHINE DESIGN in which they appeared are:

1. "Automatic Control Systems" .................. May 17, 1956
2. "Servo Mathematics" .......................... June 28, 1956
3. "Evaluating Servo System Performance—Part 1" July 26, 1956
4. "Evaluating Servo System Performance—Part 2" .. Aug. 9, 1956
5. "Analyzing Servo Systems" ...................... Nov. 1, 1956
6. "Hydraulic Servo Components—Part 1" .......... Nov. 29, 1956

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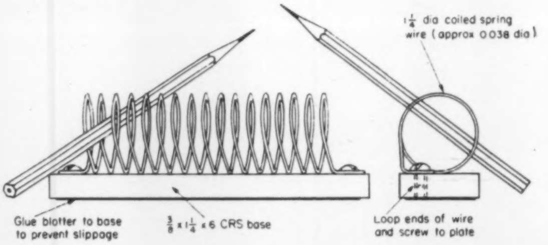
# Tips and Techniques

## *Pencil Holder*

A coil spring may be easily converted to a pencil and tool holder by stretching it and mounting on a base as shown. Dimensions and construction details shown have been quite successful. Of course, these details may vary to suit the available materials.—JOHN M. BAILEY, *Ironrite Inc., Mt. Clemens, Mich.*


1¼ dia coiled spring wire (approx 0.038 dia)
Glue blotter to base to prevent slippage
3/8 x 1¼ x 6 CRS base
Loop ends of wire and screw to plate

# *Chart gives transition points between Euler-Johnson curves for*

# Column Design

By Albert L. Gosman,* Frank R. Campbell and Richard P. Bobco*
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BUCKLING of a long, slender column under the action of an axial compressive load represents a classic example of elastic instability. Such failure by excessive lateral deflection is not a function of the yield strength of the material. Thus, if the column is long and slender, substitution of a stronger material (higher yield stress) will not necessarily increase the critical or buckling load.

As column length decreases—that is, at low fineness ratios—failure by compressive deformation of the material is a possibility, and yield strength becomes of major importance. In the intermediate range of column lengths, failure by buckling or compression (or both) can occur. Here, the approach to the column design problem is somewhat intuitive, and is usually coupled with experimental verification.

To facilitate design in this latter case, analytical expressions for column stress have been developed that encompass the entire range of lengths—from the very long, elastic member to the very short, compression member. Ideally, these expressions should span smoothly the intermediate range between the two extremes.

Such an expression, first proposed by J. B. Johnson[1], forms the basis of a working chart given in this article which enables the designer to locate the transition points between the Euler and Johnson expressions for a variety of materials and end-fixity conditions. With the transition point fixed, the applicable failure expression is known.

**Fundamental Relationships:** Critical or buckling load for the fundamental case of a long slender

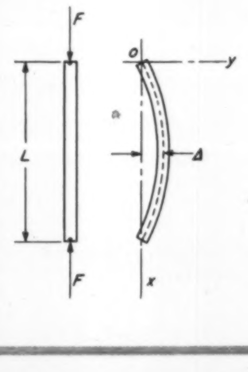

Fig. 1 — Column with pivoted ends.

**Nomenclature**

$A$ = Cross sectional area, sq in.
$C$ = Constant depending on column end conditions, dimensionless
$e$ = Eccentricity (distance of load from the neutral axis), in.
$E$ = Modulus of elasticity, psi
$F$ = Axial column load, lb
$F_a$ = Allowable or safe column load, lb
$F_c$ = Critical load for incipient deflection, lb
$I$ = Moment of inertia about the neutral axis, in.$^4$
$k$ = Least radius of gyration, in.
$L$ = Length of column, in.
$s$ = Stress due to axial load, psi
$s_a$ = Allowable or safe column stress, psi
$s_c$ = Critical stress, psi
$s_y$ = Elastic limit in compression, psi

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*Now at Northrop Aircraft Co., Hawthorne, Calif.

[1] References are tabulated at end of article.

column with pivoted ends, Fig. 1, is given by the classical Euler formula

$$F_c = \frac{\pi^2 EI}{L^2} \tag{1}$$

Assumptions inherent in this relationship are

(*a*) The load is perfectly axial.
(*b*) The column is perfectly straight before loading.
(*c*) The material follows Hooke's law as the limit of the analysis.
(*d*) The material is perfectly homogeneous.
(*e*) The column is of uniform cross-sectional area.
(*f*) Each longitudinal column fiber acts independently from adjacent fibers.
(*g*) The maximum deflection $\Delta$ is small.

It is noted that Equation 1 was developed for a column with pivoted ends and length $L$ between points of zero bending moment. This, of course, is only one of a number of possible column end conditions. A few of the other possibilities are: (1) Both ends fixed; (2) One end fixed, one end free; and (3) One end fixed, one end pivoted. Equation 1 may be applied to these cases if an equivalent length $L_1$ (as a fraction or multiple of $L$) is selected to correspond to points of zero moment or points of inflection of the elastic curve.

Since the moment of inertia $I = Ak^2$, and $L_1 = CL$, Equation 1 may be rewritten as

$$s_c = \frac{F_c}{A} = \frac{\pi^2 E}{(CL/k)^2} \tag{2}$$

In design practice, the end conditions are not always ideal. That is, for a column with both ends fixed, $C = 1/2$, indicating a critical load four times as large as that of a column with pivoted ends. Actually, the structure to which the column ends are fixed deflects slightly, thus making $C$ somewhat indeterminate. Since the end action is so indefinite, many designers consider it dangerous to use $C$ less than 1. When a column with one end fixed and one end free is considered, $C = 2$, indicating a critical load 1/4 as large as the fundamental case. This case, of course, cannot be neglected.

Equation 2 has proved to be reasonably correct for long columns. Furthermore, the simple stress equations have been shown to be quite satisfactory for direct compression in short members. It is necessary to span this gap with an equation of a smooth curve which is tangent to the Euler curve for large values of length $L$, and which is equal to the compressive strength of the material for smaller lengths.

**Intermediate Length Columns:** Johnson's parabolic formula fits the transition requirements, and numerous tests have substantiated the validity of the relationship. The parabolic equation may be written in the form

$$s_c = \frac{F_c}{A} = s_y - \frac{s_y^2 (CL/k)^2}{4\pi^2 E} \tag{3}$$

where the yield stress, $s_y$, is assumed to be close enough to the proportional limit for Hooke's law to apply.

Consider the case of a specific material whose yield stress $s_y$ is 36,000 psi. For this material Equations 2 and 3 are graphically depicted in Fig. 2 for a pivoted-end column. Note the intersection of Johnson's curve with the *Y* axis at a point corresponding to the compressive yield stress of the material. From $L/k = 0$ to $L/k \approx 30$, Johnson's curve is essentially horizontal, indicating

$$s_y = \frac{F_c}{A} \approx s_c \tag{4}$$

which is the simple case of direct compression for a short member. From $L/k \approx 30$ to $L/k \approx 130$, Johnson's curve has been experimentally verified, and may be used for this range. When $L/k > 130$, where failure occurs due to laterial deflection only, test results show that Euler's curve may be applied.

Thus a specific value of $L/k$ exists for any given material which marks the point of tangency, to the left of which Johnson's formula applies and to the right of which Euler's formula is used.

Consider the case of another material with yield stress of 60,000 psi. Equations 2 and 3 are also depicted graphically for this material (Fig. 2) when it is used in a pivoted-end column. Again, Johnson's curve is essentially horizontal for low values of $L/k$, and the point of tangency occurs at $L/k \approx 100$. This point may be found by

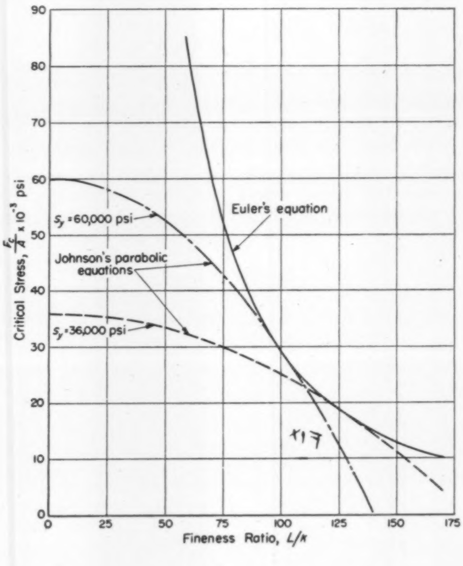

Fig. 2 — Point of tangency between Euler and Johnson equations.

equating Euler's equation to Johnson's formula as follows:

$$\frac{F_c}{A} = \frac{\pi^2 E}{(CL/k)^2} = s_y - \frac{s_y^2 (CL/k)^2}{4\pi^2 E} \qquad (5)$$

which, when solved for $L/k$, becomes

$$L/k = \frac{4.44}{C}\sqrt{\frac{E}{s_y}} \qquad (6)$$

Equation 6 may then be used to determine the point of tangency for any material for which $s_y$ and $E$ are known, providing that the column conditions fall within the assumptions previously noted.

A log-log plot of Equation 6 is shown in Fig. 3 with the modulus of elasticity $E$ and the end-fixity constant $C$ as parameters. Plotted on the abscissa are values of $L/k$ for $C = 1$ (pivoted ends), and $C = 2$ (one end fixed, and one end free). It is noted from Equation 6 and Fig. 3 that, for any constant $E$, the higher the compressive strength of the material, the lower the resulting $L/k$ point of tangency.

Johnson's formula is, of course, only one of many relationships which may be used for intermediate values of $L/k$. The Rankine-Gordon formula, or any of the many variations of empirical straight-line formulas, can also be made to apply merely by proper selection of constants. Therefore, if it is desired to use any of these other relationships, rather than Johnson's formula, a working chart giving points of tangency may be found in a similar manner.

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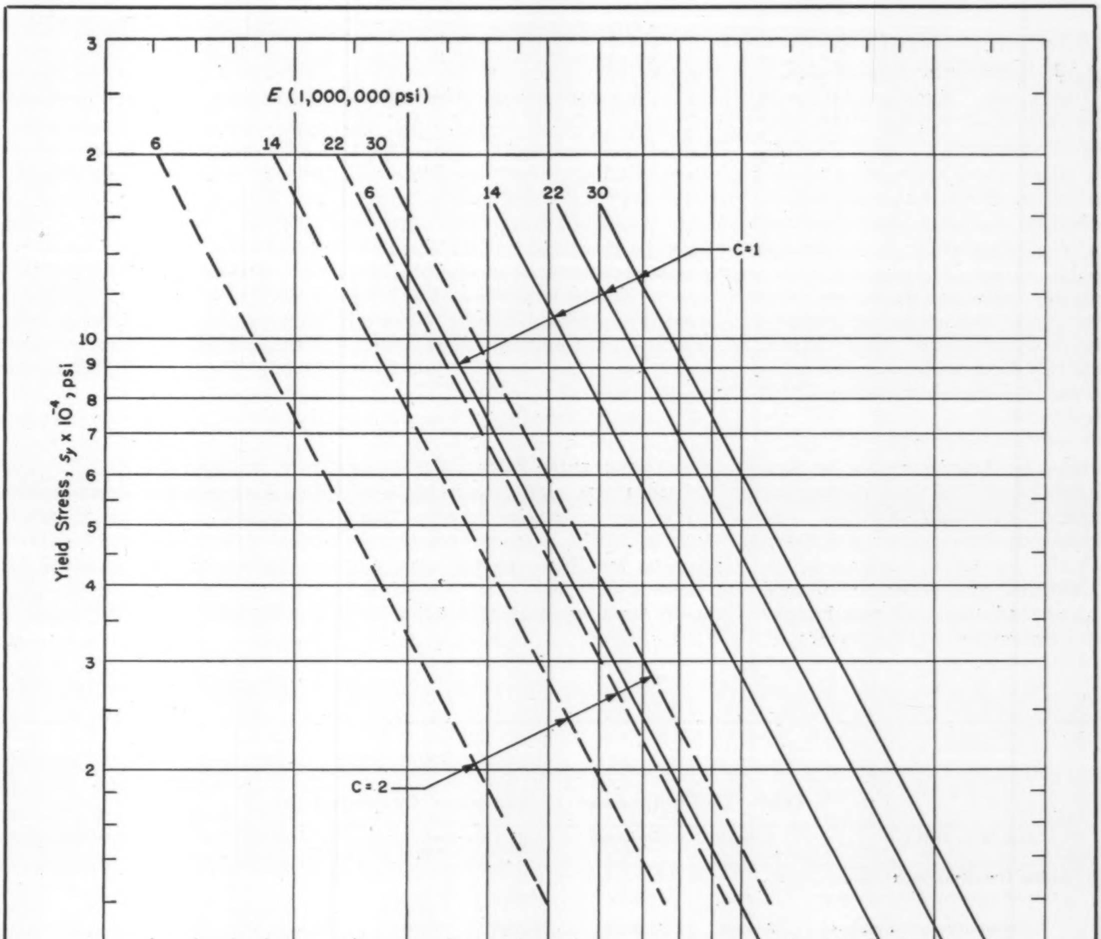

Fig. 3 — Curves of tangency between Euler's and Johnson's equations for range of modulus of elasticity.

# Comparing Analog and Digital Computers

## *for solving design problems*

MAJOR differences between analog and digital computers stem from their fundamentally different approach to mathematics. The digital approach permits the use of nothing but elementary arithmetic operations and "yes" or "no" decisions, while the analog approach is one of functional relationships between dependent and independent variables. Any application of computers which varies from this premise does so by making use of additional mathematical formulation.

Where it is possible to obtain comparable data by analog or digital computer, the final choice depends on necessary accuracy, set-up and calculation times associated with the particular computers, total amount and repetitive nature of the calculation, and past history and preferences of the personnel involved.

The general-purpose computers used today may be placed roughly in four classes having different computational properties, Table 1. These are the electric analog computer composed mostly of passive elements, the electronic differential analyzer using operational amplifiers to perform mathematical operations on analog voltages, the externally-stored program digital machine, and the internally-stored program digital machine.

The electric analog computer is characterized by its large number of elements, rapid calculation, limited accuracy, and a set-up time which is relatively short. The electronic differential analyzer usually has smaller capacity, greater potential accuracy, about the same set-up time, greater flexibility in the treatment of non-linear functions, and somewhat longer calculation time than the electric analog computer.

The two digital classes differ primarily in the flexibility of the program, with the internally-stored program machine being able to modify its own program as the result of calculation. More through the chronology of development than inherent properties, the externally-stored program machine usually has limited number storage and is a slow or medium-speed machine, while the internally-stored program machines range from medium speed and storage to the most powerful computers built. Compared to the analog machines, some characteristics of digital machines are more set-up time for the initial calculation but less for any subsequent ones from the same program, accuracy limited only by

Table 1—Comparison of Computer Characteristics

| Type of Computer | Capacity | Calculation Time | Set-Up Time | | Accuracy (per cent) | Treatment of Nonlinearities |
|---|---|---|---|---|---|---|
| | | | Initial | Repeat | | |
| **Analog** (functional relationships) | | | | | | |
| Electric analog (passive element) | Large | Short | Medium | Short to medium | 1 to 5 | Difficult |
| Electronic differential analyzer | Medium | Medium | Medium | Short | 0.1 to 5 | Easier than electric analog |
| **Digital** (elementary arithmetic) | | | | | | |
| Externally stored program | Limited by internal storage | Long to medium | Long | Very short | Limited only by math involved | Easy if analytic, difficult if arbitrary |
| Internally stored program | Unlimited | Medium to short | Very long | Very short | Limited only by math involved | Easy |

# DESIGN ABSTRACTS

By D. B. Breedon

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*Analytical Dept.*
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the mathematics involved, simpler handling of arbitrary functions, more awkward formulation of differential equations, and extremely rapid arithmetic.

**Problem Characteristics:** The characteristics of computers discussed briefly in the foregoing can take on their proper perspective only when considered with respect to a particular type of problem. Without attempting to fit every problem that the engineer encounters into a neat little slot, a few general types can be established.

One large class of calculations involves straight data conversion by numerical operations according to fixed rules or formulas. This type of computation is almost certainly done more economically by digital computer, the type being determined by magnitude of the problem. At the other end of the spectrum is the large class of problems arising from the transient behavior of control systems. These are handled most easily by the electronic differential analyzer because of the direct representation of time-differential equations possible on this computer.

Transient behavior of systems involving partial differential equations such as electrical power systems or mechanical structures is best studied on the electric analog computer because of its large number of elements and the ease of handling the mathematics. This problem could be solved by differential analyzer, but the size of the system would be drastically limited by the size of the computer since approximately one amplifier would be needed for each passive element of the other representation. This problem could also be solved by digital means but only on the most powerful computer and at the expense of much time and effort, since the formulation for numerical solution is extremely lengthy and requires much calculation time compared to the analog techniques.

Less well defined is the class of static boundary-value problems. The electric analog computer is just as applicable to these as to the transient cases, but now the digital solution appears in a much more favorable light. The decision for analog or digital computation must be based on more information. If the problem is not expected to occur again later and, especially, if a number of variations are to be calculated at the same time, the short set-up and calculation times of the electric analog make it preferable; but if the problem is expected to recur frequently with only a few cases each time, the short set-up time of the digital solution after the initial program has once been written would probably compensate for the longer calculation time. The digital solution may be justifiable initially on the basis of increased accuracy beyond the 1 or 2 per cent of the analog, but the digital solu-

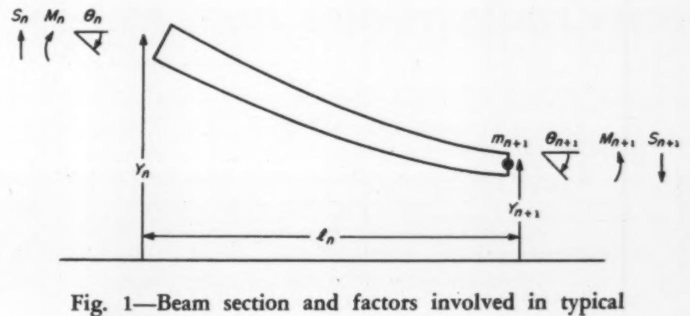

Fig. 1—Beam section and factors involved in typical problem.

tion also is only as accurate as the representation.

Another class of calculations which may include elements of the above types and where each case must be examined individually is optimization of design. Depending on the type of calculations performed in the optimization, the decision may be clear-cut, but where either computer is applicable, the ease of parameter variation in the analog must be weighed against the automatic decision-making features of the digital computer. The frequency with which the problem is encountered is likely to be the deciding factor.

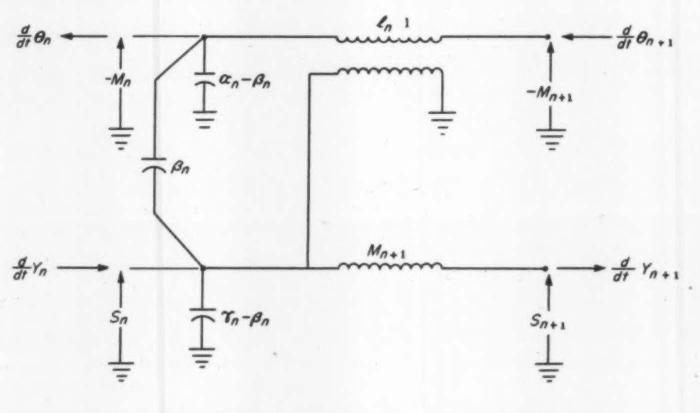

Fig. 2—Mass-inductance passive element analog.

**Typical Problems:** The following examples illustrate typical uses of automatic calculation:

1. TRANSIENT BEHAVIOR OF MECHANICAL SYSTEMS COMPOSED OF COUPLED BEAMS: Many mechanical structures of interest to the engineer fall into the general class of coupled beams. Once a preliminary design for a structure has been arrived at, one or more different types of analysis may be necessary to prove the design. Probably the most difficult data even to estimate by hand methods are the stresses and deflections experienced under the influence of some transient shock.

One approach to simplification of the mathematics is to reduce the partial differential equations to a set of ordinary differential equations by considering the finite difference equations at points along the lengths of the beams. If the mass is considered lumped at discrete points, equations relating the physical quantities at the ends of a section as shown in Fig. 1 may be written as follows:

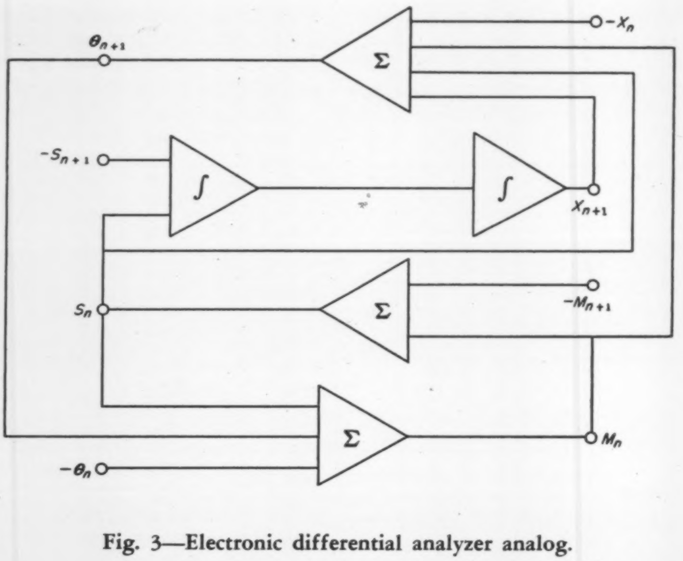

Fig. 3—Electronic differential analyzer analog.

$$S_{n+1} = S_n - m_{n+1}\frac{d^2}{dt}Y_{n+1} \quad (1)$$

$$M_{n+1} = M_n + l_n S_n \quad (2)$$

$$\theta_{n+1} = \theta_n - \alpha_n M_n - \beta_n S_n \quad (3)$$

$$Y_{n+1} = Y_n - l_n \theta_{n+1} - \beta_n M_n - \gamma_n S_n \quad (4)$$

where $\alpha_n$, $\beta_n$ and $\gamma_n$ are elastic coefficients and $S$, $M$, $\theta$ and $Y$ are shear, moment, angle and displacement, respectively.

A digital transient solution to the system made up of a number of sets of these equations is admittedly possible, and other approaches may yield an easier digital solution. However, the preparation of a program having sufficient flexibility to handle general problems of this type would be an enormous task.

A number of relatively simple analogs representing Equations 1 through 4 are obtainable. Two of these are shown in Figs. 2 and 3. Fig. 2 is a mass-inductance passive element analog, while Fig. 3 is an electronic differential analyzer analog.

These analogs are relatively easy to set up and interconnect to satisfy boundary conditions of complex structures. Though the total number of sections represented is limited by the amount of equipment available and by the accuracy of the elements, the choice of analog

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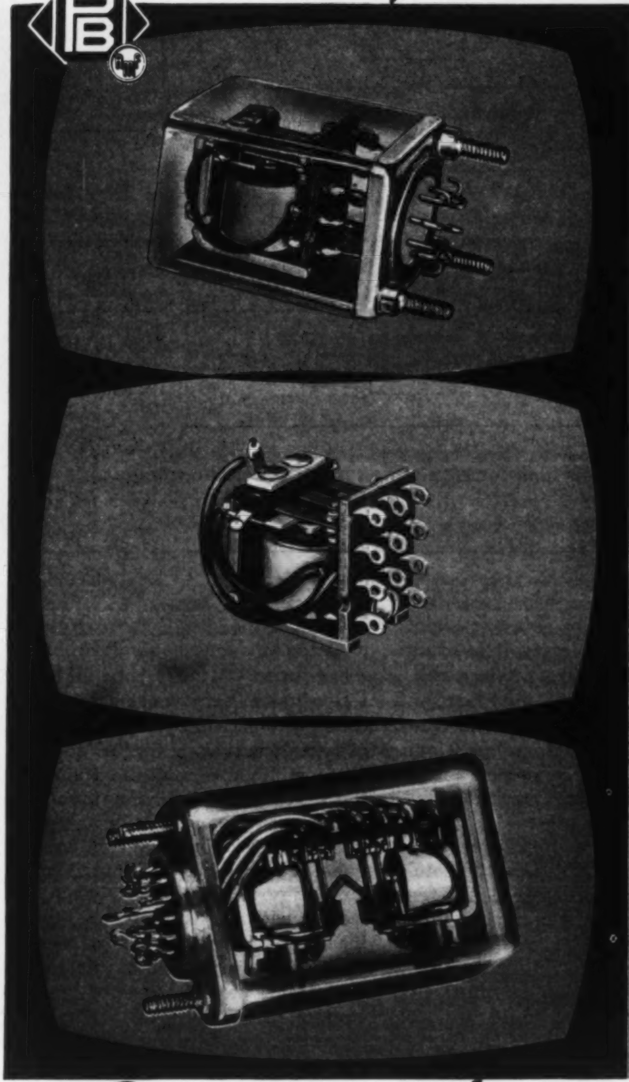

A three-pole, hermetically sealed version of the KM provides a multiplicity of action yet requires a minimum of space. Mounted with three #6-32 studs; eight solder terminals. This relay is especially useful in low voltage, DC applications where size and weight are critical factors.

**ENGINEERING DATA**
**KM SERIES**

**CONTACTS:** Max. 3PDT. 3/32" Dia. Silver 2 amps. 115V 60 cy. resistive
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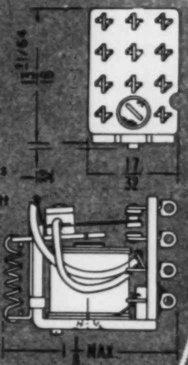
**COIL RESISTANCE:** Up to 6700 ohms
**COIL POWER REQUIREMENT:** 1 watt
**TEMP RANGE:** −45° C to +55° C
**PULL-IN:** 75% of nominal voltage
**TERMINALS:** Solder lugs



Designated as the KE, this latching relay combines two KMs for minimum size and weight. It operates on momentary impulse to either coil with a mechanical latch and electric release. Available up to 6 PDT. This relay was designed for intermittent duty only. Three-stud mounted with solder terminals. Hermetically sealed model is shown at left. Also available in open version.

## *Good Relay News!* KM SERIES ANSWERS DESIGN NEEDS

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**POTTER & BRUMFIELD, INC.** A Subsidiary of American Machine & Foundry Co.
PRINCETON, INDIANA
Manufacturing Divisions in Franklin, Ky., and Laconia, N. H.

*Circle 576 on page 19*

equipment over digital computer is clearly indicated by the ease of handling the mathematics and the associated shorter set-up time.

2. NATURAL FREQUENCIES OF COUPLED BEAMS—CRITICAL SPEEDS: In a large number of mechanical problems, only the natural frequencies and the stresses associated with them are of primary interest. One such case is the design of turbine-generator rotors where the natural frequencies must not coincide with the running speed or its harmonics.

The frequencies may be obtained from the same analogs used for transient work, but in this case the prospects for digital calculation are much brighter. Since the motion of any point in the structure will be sinusoidal with time when a single natural frequency is excited, Equation 1 may be rewritten as:

$$S_{n+1} = S_n + m_{n+1}\,\omega^2\,Y_{n+1} \qquad (5)$$

Now Equations 2 through 5 may be employed in a calculation to obtain the desired frequencies. Comparing the essentially constant set-up time, limited capacity and limited accuracy of the analog solution with the short set-up time after the initial programming, unlimited capacity, high accuracy and smaller chance for error of the digital solution, the choice of digital solution is well defined. The one possible exception to this is a situation where a large number of relatively minor variations are to be examined at one time. In this case, the short solution time may make the passive analog method the more attractive.

3. REGULATING SYSTEMS: The regulation of the voltage of a turbine generator is a representative example of a complex feedback control system. Fig. 4 is a block diagram of the regulating system and is presented to illustrate the complexity of the problem.

The straightforward approach to most regulating systems is provided by the electronic differential analyzer. This problem is no exception in that the differential analyzer will provide the most data on the transient response with the least effort. However, with systems of this complexity it is often difficult to foresee the best approach to system modification when the analog indicates an unacceptable solution. Some additional information, or some better evaluation of the same information, is often desirable.

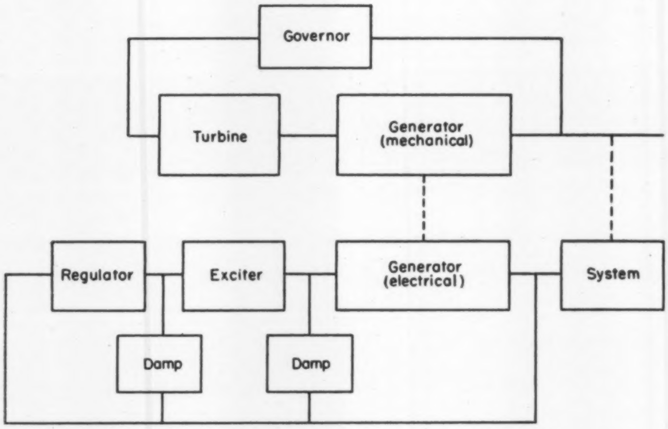

Fig. 4—System for regulating turbine-generator voltage.

A digital approach to transient response based strictly on the solution of the differential equations would not yield anything new and in addition would be more difficult than the analog solution. However, the information supplied by phase-gain analysis, while it does not yield accurate transient data, is quite useful for qualitative prediction. A digital computer is admirably suited to the computation of this type of data, whereas phase measurements from an analog are not altogether satisfactory.

Thus, there are some problems where analog and digital machines can work together profitably.

**Conclusions:** Providing an analog can be devised, transient problems involving partial differential equations are best handled on a passive element electric analog computer. The electronic differential analyzer is less satisfactory because of capacity limitations but offers some compensation in handling nonlinearities.

Transient and control problems based upon ordinary time-differential equations are most easily handled by electronic differential analyzer. However, a digital solution is feasible and may be indicated by a repetitive problem involving highly nonlinear functions.

Most static boundary-value and quasi-steady-state oscillatory problems may be solved nearly equally well by either analog or digital means. Low frequency of occurrence and many minor parameter variations indicate use of analog equipment. Repetitive set-up and extreme accuracy and capacity requirements indicate use of digital computer.

Data-reduction problems and economic optimization based on a choice of functionally similar designs are best handled digitally.

A large number of calculations, primarily performance calculations, may be approached by different paths on analog and digital computers. The use of both approaches to obtain complementing data is often worthwhile.

*From a paper entitled "Analog Versus Digital Techniques for Engineering Design Problems" presented at the Fifth Annual Industrial Electronics Symposium sponsored by IRE and AIEE, in Cleveland, September,* 1956.

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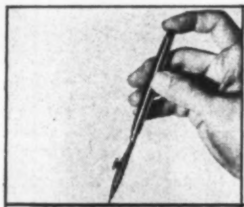

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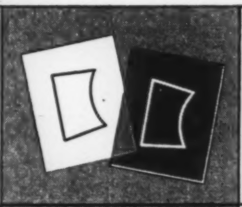

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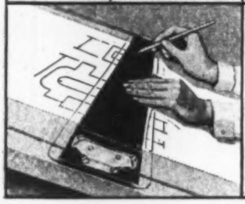

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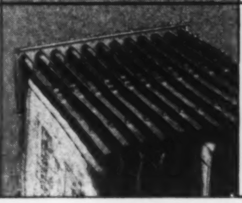

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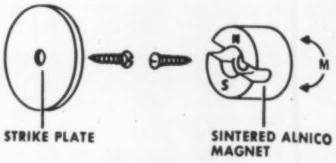
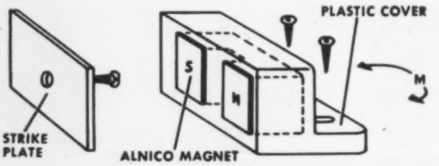
# A survey of
# *Magnetic Latches*

By Richard A. Scholten
*Design and Application Engineer*
*Indiana Steel Products Co.*
*Valparaiso, Ind.*

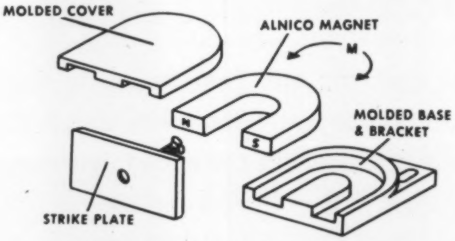
PERMANENT-MAGNET latches offer unique application possibilities. Pictured here are some of the more popular types with descriptions of their design features. *From "A Survey of Magnetic*


STRIKE PLATE
N
S
M
SINTERED ALNICO MAGNET

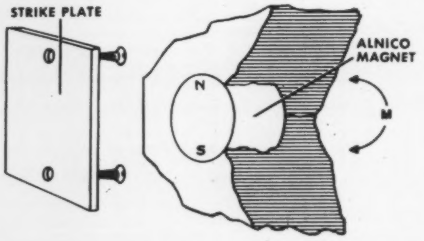
**1.** Small Sintered Alnico II magnets of the round two-pole type which provide simple, inexpensive latches where magnetic strength is not too important. May be mounted by tacks, screws or glued in drilled holes in nonmagnetic material.


PLASTIC COVER
S
N
M
STRIKE PLATE
ALNICO MAGNET

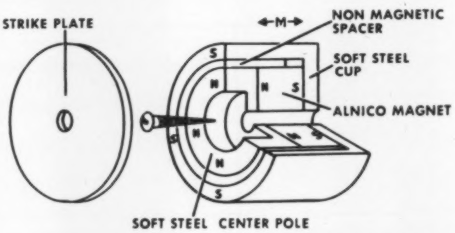
**2.** Latch consisting of a simple U-shaped Alnico magnet inserted in a molded plastic or die cast cover. Covers a wide range of magnetic strength and provides good performance under gap conditions.


MOLDED COVER
ALNICO MAGNET
M
N
S
MOLDED BASE & BRACKET
STRIKE PLATE

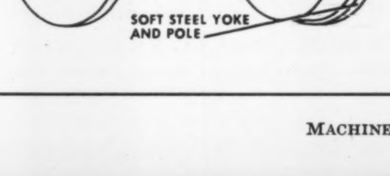
**3.** Similar to Fig. 2, except magnet is held loosely in assembly, thereby simplifying alignment with strike plate.


STRIKE PLATE
ALNICO MAGNET
N
S
M

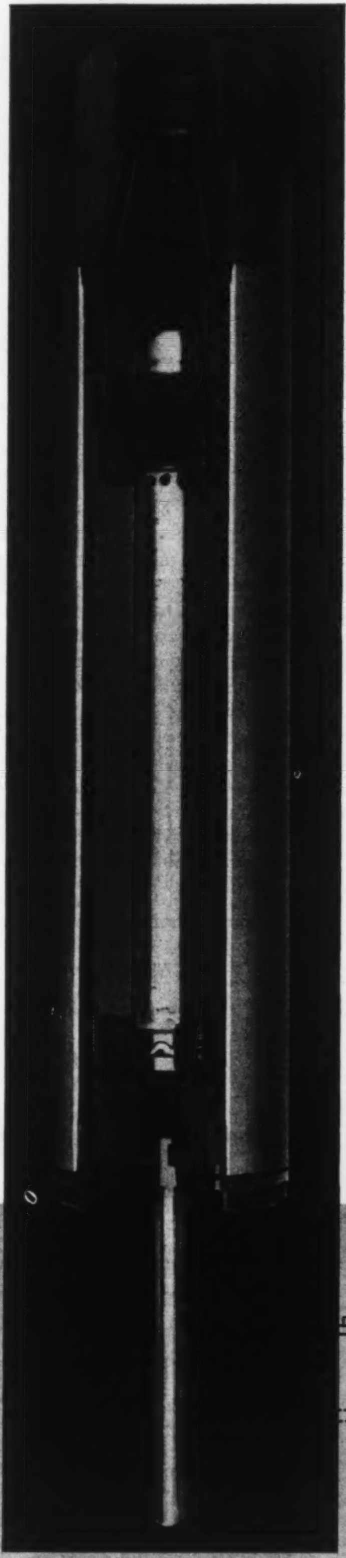
**4.** Round flat-faced magnet magnetized with two poles on the contact face. Usually Alnico V or Alnico VI, with preferred magnetic axis perpendicular to contact face. Has moderate strength but is simple and neat in appearance for deluxe cabinet applications.


STRIKE PLATE
←M→
NON MAGNETIC SPACER
SOFT STEEL CUP
ALNICO MAGNET
N
S
SOFT STEEL CENTER POLE

**5.** Cup-type Alnico assembly giving very great strength at direct contact for minimum space and material usage. Generally expensive.


STRIKE PLATE
INDOX MAGNET
←M→
N
S
SOFT STEEL YOKE AND POLE

**6.** Ring-type assembly using Indox I magnet. Soft-steel center pole provides high flux density for greatest pull.



# 7 "bonus values" of Leland's submersible motor!

Now both motor and pump can be installed right in your gasoline storage tank! Even with high octane gasolines, the new Leland explosion-proof motor eliminates vapor-lock . . . uses the gasoline itself for lubrication and cooling. This completely new ¾ hp, 230v AC thermally protected motor measures only 3½ inches in diameter . . . fits into existing tanks. It's fully U.L. Approved for Class I, Group D service.

Simple and rugged, built for long-life economy, this new Leland submersible pump motor has these 7 big advantages over other motors:

1. Completely self-contained unit includes outer shell necessary for gasoline passage — makes expensive extras unnecessary.
2. Extruded aluminum outer shell becomes main structural member — ribbed design provides much needed rigidity.
3. 9⁄16" chrome-steel shaft extension provides greater strength—prevents mechanical distortion.
4. Increased annular area allows 10% greater gasoline flow—minimizes trouble-making back pressure and turbulence.
5. Suction stub mounts without adaptor castings — reduces expense required with other motors.
6. Plastic-impregnated windings surpass wet-design insulation requirements — remain trouble-free for extra-long service life.
7. Leland's integrated motor design permits complete removal of pump or stub *without* disassembling motor.

In addition . . . a remote-control box is supplied with each Leland submersible pump motor. Includes thermal overload protector, line control and starting relays, starting and running capacitors.

30 years ago Leland developed the first gasoline curb pump motor to receive U.L. Approval — today, Leland gasoline pump motors outsell all others combined. So there's good reason why, for explosion-proof motors of any kind, your best bet is Leland. If you would like more information, and/or a copy of a new brochure on the submersible motor, write, wire or phone us — TODAY!

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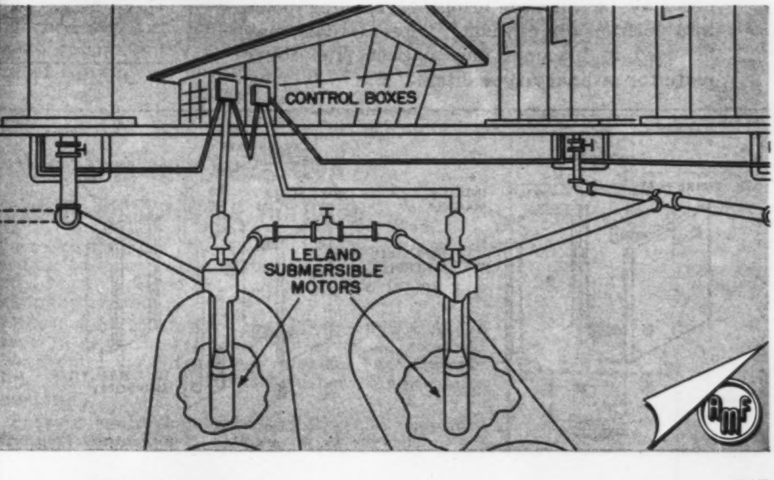
Dayton 1, Ohio
Division of AMERICAN MACHINE & FOUNDRY COMPANY

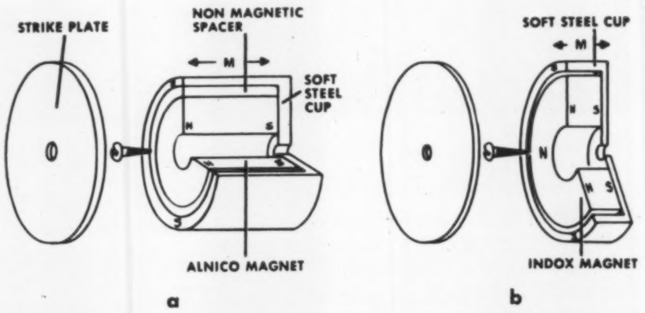


Circle 578 on page 19

*Latches" in* Applied Magnetics, *Published by Indiana Steel Products Co., October-December,* 1956.

**7a.** Simplified Alnico cup-type assembly, with slug-type magnet held inside a steel cup. Is more effective than same magnet in Fig. 5, however, less effective at small gaps. Magnet may be mounted with screw in center or pressed into hole.

**7b.** Indox cup assembly, with Indox magnet glued in steel cup. Has good direct contact and gap pull.


STRIKE PLATE
NON MAGNETIC SPACER
M
SOFT STEEL CUP
N
S
ALNICO MAGNET
a
SOFT STEEL CUP
M
N
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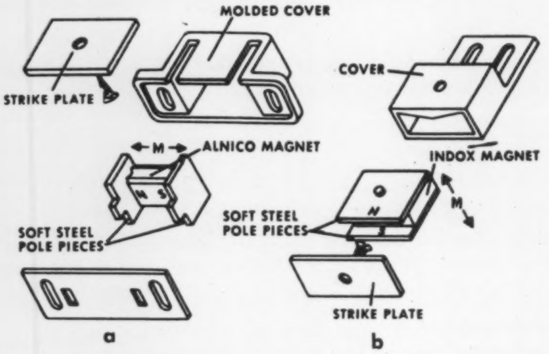
N
S
INDOX MAGNET
b

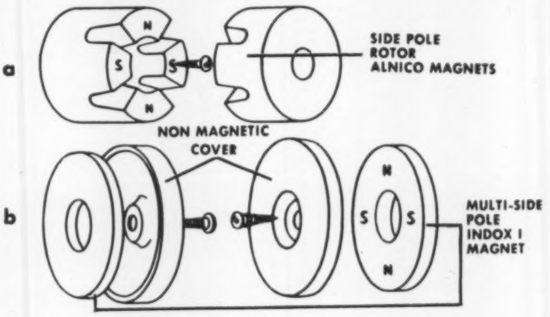

MOLDED COVER
STRIKE PLATE
M
ALNICO MAGNET
N
S
SOFT STEEL POLE PIECES
a
COVER
INDOX MAGNET
N
M
SOFT STEEL POLE PIECES
STRIKE PLATE
b

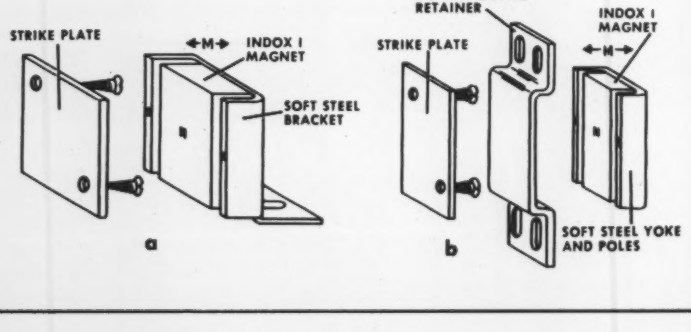
**8a.** Practical assembly where quantities warrant proper tooling. Magnetic circuit design using soft steel poles spaced by single Alnico bar magnet provides maximum contact pull for minimum of permanent magnet material. Is less effective through gaps. This basic magnetic circuit, in combination with a great variety of mechanical assembly designs in which parts are mounted loosely for self aligning feature, is very popular for mass, cabinet-latch market.

**8b.** Simple modification of Fig. 8*a* to use Indox I permanent magnet. High coercive force permits flat "sandwich" type circuit in a variety of mechanical retainers. Design becoming very popular.

**9a.** Cast Alnico magnets of side-pole rotor type which provide great strength both at direct contact and at gaps. Rotation of one magnet brings repelling poles into position for simple releasing. Steel washer may be used in place of one magnet for ordinary type latch.

**9b.** Indox I ring magnets magnetized with poles on face, using nonmagnetic cover to protect Indox from breakage and to provide for mounting. Has low pull at small gaps but is very efficient for large gaps. One magnet may be rotated, bringing repelling poles into position for releasing. Steel washer may be used in place of one magnet plus cover plate for ordinary type latch.


a
N
S
S
N
SIDE POLE ROTOR ALNICO MAGNETS
NON MAGNETIC COVER
b
N
S
S
N
MULTI-SIDE POLE INDOX I MAGNET


STRIKE PLATE
M
INDOX I MAGNET
N
SOFT STEEL BRACKET
a
NON MAGNETIC RETAINER
STRIKE PLATE
INDOX I MAGNET
M
N
SOFT STEEL YOKE AND POLES
b

**10a.** Simple Indox I assembly. Has less contact pull than that in Fig. 8*b*.

**10b.** Simple Indox I assembly with mounting method to provide self aligning and different positioning. Large pole-face on magnet gives low-reluctance path for flux through the retainer; however, less pull will be produced than for assembly in Fig. 10*a* due to effective air-gap on magnet caused by retainer.

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## Technical-ities

By John S. Davey

### Bolts take greatest stress during wrenching

If a bolt doesn't fail when being wrenched up tight, it won't fail in service (assuming bolts and joint have been designed adequately for the loads).

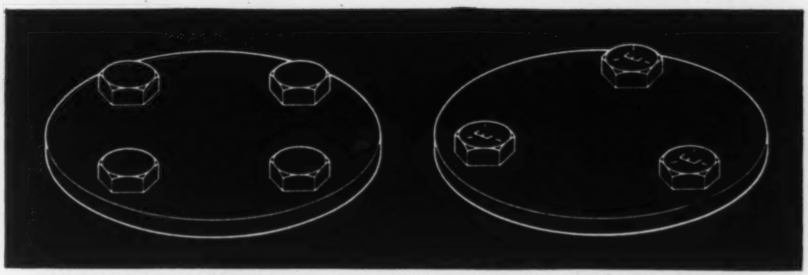
That's because two forces put stress on bolts (and cap screws) as they tighten: Tension due to bolt stretch; torsion due to friction. But only tension remains after wrenching. In a rigid joint, if this tension exceeds external forces, bolts will never experience any further strain, and will therefore not loosen or fail.

**WHY SOME FAILURES?**

Obviously, unusual unforeseen loads cause trouble. The instant they exceed residual tension, *they add* to the stress placed on the bolt and can cause *immediate* failure. Or they can cause loosening, leading to stress change, which in turn causes fatigue and failure. That's why you've got to torque bolts tight . . . and the tighter the better.

An exception: A flexible joint. With high cyclic loading, again loosening and fatigue cause trouble. Since you shouldn't tighten such a joint too much, sometimes the only remedy is to take out the flexible element and put in a rigid joint. (A metal to metal flange connection instead of a gasketed one, for example.)

## Are you using more bolts than needed?



The stability of a 4 bolt arrangement can be matched by a 120° spacing of 3 bolts. Strength can be actually increased by using RB&W high carbon heat treated bolts (identified by "E" and three radial dashes).

NOBODY wants to use too few bolts or cap screws and risk failures. But using too many is not the best answer either. It means too many holes to drill, to fill — both costly.

RB&W offers some suggestions.

**BALANCED BOLT PATTERN**

By "rule of thumb," bolts are generally arranged symmetrically in a pattern of four. Yet three bolts 120° apart around a common center will prove just as stable, and save on assembly. With stability assured, the problem is then one of load capacity.

**PRELOAD TO GET FULL CAPACITY**

In checking size and number of bolts, calculate the stress and get rid of the excess. You have enough if you've allowed for usual factor of safety . . . *and the fasteners are tightened so that residual tension exceeds maximum external load anticipated.* If they are, you have safety. The bolts will *stay* tight, won't fatigue, won't fail.

With RB&W standard fasteners, engineers and production men can take quality, uniformity and dependability for granted — and can concentrate on the problem of proper application and assembly. For help or information on your specific product, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

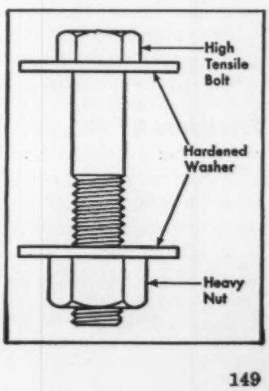
**Plants at:** Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

### High strength bolts stop joint failure from vibration

Shakeout equipment used by one company for unloading coal cars applied its vibration via a fabricated frame lowered onto the cars. This frame was originally riveted.

But it was a constant source of maintenance. About every 10 days, the frame had to be welded, loosened rivets replaced. Finally it was refastened with RB&W high tensile bolts and hardened washers. Maintenance now is *nil!*

Proving again that high strength bolts make the strongest connection for the severest service.



Circle 579 on page 19

# HELPFUL LITERATURE

## for Design Executives

**For copies of any literature listed, circle Item Number on Yellow Card—page 19**

### Electronic Equipment

Control system analyzers and synthesis equipment, servo amplifiers, electromechanical assembly kits, signal generators, pyrometers, heat detector cells, photometers, direction finders and communications receivers are some of the electronic systems, equipment and components detailed in short form catalog SF-9901. 16 pages. Servo Corp. of America.

***Circle 401 on page 19***

### Small-Lot Stampings

Techniques employed in economically producing stampings in small lots to customers' requirements are related in illustrated bulletin 151. In addition to explaining precision piercing and blanking methods, suggested basic designs for metal stampings are shown. 24 pages. Dayton Rogers Mfg. Co.

***Circle 402 on page 19***

### Corrosion Resistant Materials

Brief descriptions of Tygon flexible plastic tubing, gasketing, protective coatings, tank linings, corrosion resistant masonry and chemical ceramics are given in illustrated bulletin S-1 1801. Also covered are fabricated towers of various types and tower packing. 8 pages. U. S. Stoneware Co.

***Circle 403 on page 19***

### Heat Transfer Units

Data on how to cut heat transfer costs in a wide range of industrial applications are among contents of illustrated bulletin IP-356. Construction details are shown, and ten advantages of Platecoil units are listed. Sketches show 14 actual installations. Tranter Mfg., Inc. Platecoil Div.

***Circle 404 on page 19***

### Fractional HP Motors

Line of fractional horsepower direct current permanent magnet motors, as well as gearheads, centrifugal blowers and tachometer generators, is subject of condensed illustrated catalog F 4344-3. Motors are 6 to 115 v dc units with outputs to 1/10-hp and speeds from 5000-20,000 rpm. 4 pages. Barber-Colman Co., Aircraft Controls Div.

***Circle 405 on page 19***

### Fabricated Steel Tubing

Advantages of having steel tubing partly fabricated to your designs are described in illustrated folder PO 2256. Zincgrip (tightly zinc coated) and Aluminized (aluminum coated) special types are available. Sections on machining operations are included. 4 pages. Armco Steel Corp.

***Circle 406 on page 19***

### Retractile Cords

Wide range of applications for line of retractile cords in industry and other fields is found in illustrated catalog 556. The springlike cords extend to about six times their retracted length. Specifications for standard types are given. 12 pages. Koiled Kords, Inc.

***Circle 407 on page 19***

### Variable Speed Motor Pulley

Improvements made in the No. 800 Vari-Speed Jr. motor pulley are outlined in illustrated bulletin V-563. Five sizes range from ⅛ to 1½-hp capacity, with ratios up to 2.75:1 and speeds from 135 to 1965 rpm. Design details are shown. 8 pages. Reeves Pulley Co.

***Circle 408 on page 19***

### Electronics Alloys

"Pennrold Precision Strip for Electronics Applications" presents case history and other data on thin-gage beryllium copper, phosphor bronze, nickel silver, chromium copper, stainless 17-7 PH, Invar and magnetic strip down to 0.0005-in. thick. 8 pages. Penn Precision Products, Inc.

***Circle 409 on page 19***

### Nylon Pressure Tubing

Properties and applications of Nylaflow nylon pressure tubing are detailed in illustrated bulletin "A Case History of Engineering Progress." 8 pages. Series of 2-page case histories and technical bulletins cover specific applications and properties. Polymer Corp. of Pennsylvania.

***Circle 410 on page 19***

### Production Facilities

Examples of products that can be produced by this company are shown in bulletin. Included are large crankshafts, aircraft forgings, machinery assembly, hydraulic press rods, ordnance parts, cylinder blocks, boat shafting, press cylinders and flame hardened rolls. 4 pages. National Forge & Ordnance Co.

***Circle 411 on page 19***

### Two-Way Valves

Two-way directional control valves for fluid power systems up to 3000 psi are described and illustrated in bulletin 80200. Construction details are given. Wide choice of plungers and flanges is offered in five styles of operators. 16 pages. Oilgear Co.

***Circle 412 on page 19***

### Heat Treating Beryllium Copper

Methods and procedures used to heat treat beryllium copper wrought and casting alloys are described in catalog. Tables of physical and engineering properties are included. 8 pages. Beryllium Corp.

***Circle 413 on page 19***

### Vibration Pickups

Bulletin 124E on MB velocity-type pickups includes data on design and method of operation, specifications and typical frequency-response curves for damped and undamped types. Model M-1 and M-3 vibration meters are also covered. 6 pages. MB Mfg. Co.

***Circle 414 on page 19***

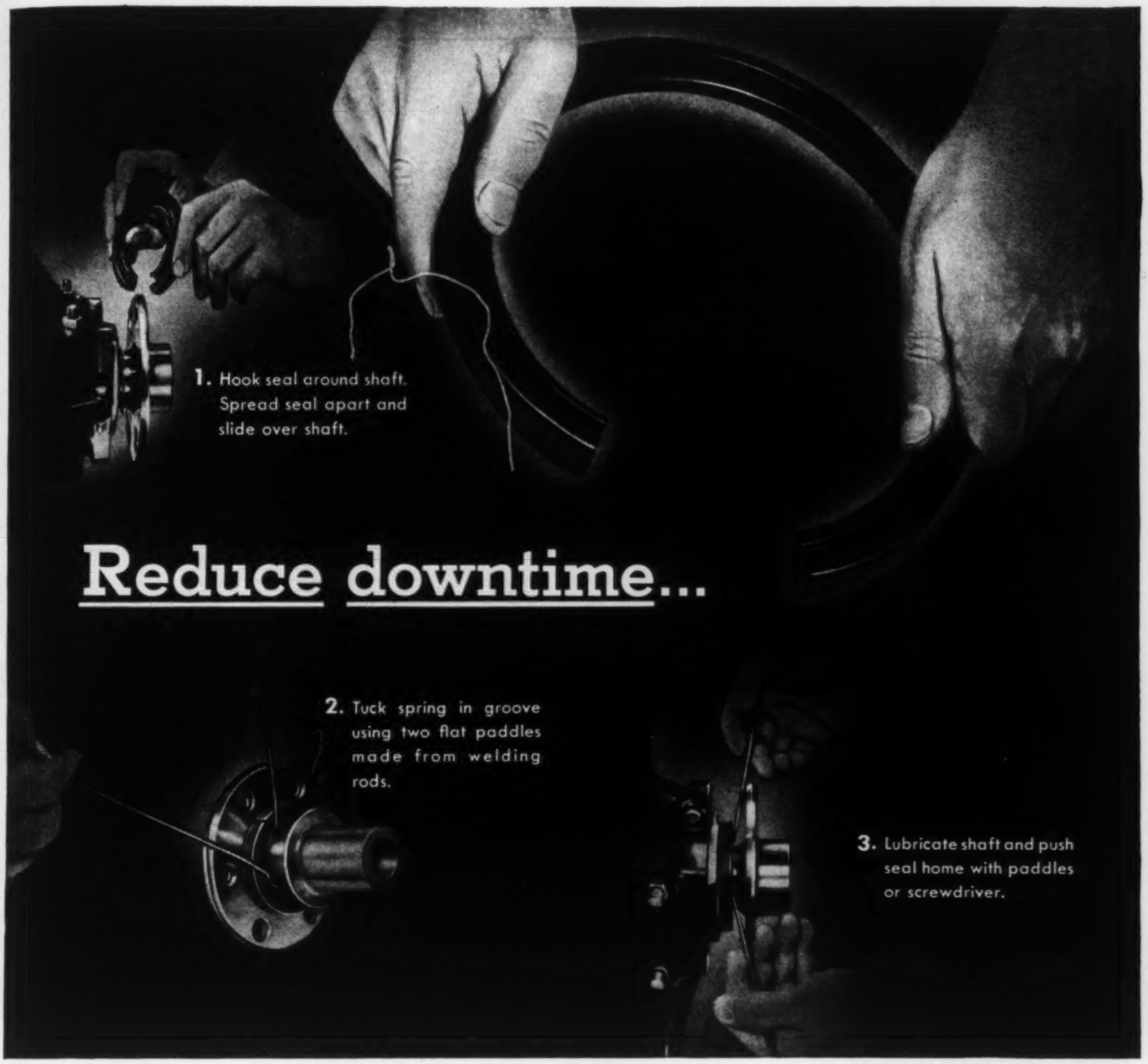
### Tracing Papers

Samples of three tracing papers and price list are provided in file folder. Included are a fast tracing vellum for all process reproductions; a rag natural bond tracing stock; and an economical tracing paper with fast speed. Latmer Sales Co.

***Circle 415 on page 19***

### Insulation Material

In addition to thermal and acoustical performance, form WML-5 briefly describes how Microlite insulation is made and what it is made



**1.** Hook seal around shaft. Spread seal apart and slide over shaft.

# Reduce downtime...

**2.** Tuck spring in groove using two flat paddles made from welding rods.

**3.** Lubricate shaft and push seal home with paddles or screwdriver.

## How J-M Split Clipper Seals speed installation

**. . . flexible body provides easy installation and removal even with small clearances**

"Downtime" is measured in seconds when Clipper Seals do your sealing. Furnished in split form and made from a highly flexible synthetic rubber compound, they can be readily slipped into the tightest spots. Neither special training nor special tools are required . . . no drilling and tapping for cover plates is necessary because cover plates are not needed.

Clipper Seals are virtually fracture-proof and stand up well under rough handling by inexperienced mechanics. The self-adjusting garter spring has a hook and eye which is easily hooked around the shaft. It is then a simple procedure to slip it into the groove. When the shaft end is accessible, solid seals are used and snap into place almost as quickly as you can say "Clipper Seal." What's more, they stay put.

Reduced "downtime" is only one of many advantages you get with J-M Clipper Seals. Precision moulded from a variety of corrosion-resistant compounds specially developed for each service, they provide maximum sealing ability, low torque, long life and wide adaptability. For more information on the complete line of Clipper Seals, write for new 28-page illustrated brochure PK-71A. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville CLIPPER SEALS**

*Circle 580 on page 19*

of. Uses in heating and air conditioning systems, appliances and in industry are pointed out. 4 pages. L.O.F. Glass Fibers Co.

*Circle 416 on page 19*

### Adjustable Speed Drive

Control station, adjustable-speed drive motor and the control unit comprise the Xatron V-S drive described in folder D-2351. Drive utilizes an Xatron tube to rectify incoming ac to provide source of adjustable dc power to drive motor. 4 pages. Reliance Electric & Engineering Co.

*Circle 417 on page 19*

### Plastic Products

In addition to information on chemical, electrical and mechanical properties of Teflon and Raylon, brochure 6905 also provides specification on various sizes in which sheets, tape, molded and extruded rods and tubes in these plastics are available. 8 pages. Raybestos-Manhattan, Inc., Plastic Products Div.

*Circle 418 on page 19*

### Thermocouple Accessories

Adapters, resistors, terminals, as well as firewall, bayonet and quick-disconnect connectors are among thermocouple accessories described in bulletin 1610-A. Cross reference of products arranged by AN equivalents is included. 4 pages. Revere Corp. of America.

*Circle 419 on page 19*

### Round & Square Tubing

Tolerances and additional size ranges for square, rectangular and round carbon and stainless steel welded Electrunite tubing are provided in reference data available in wall, desk and pocket type charts. Physical properties are set forth as welded normalized, drawn and mandrel drawn. Republic Steel Corp., Steel and Tubes Div.

*Circle 420 on page 19*

### Fractional HP Motor

Included in brochure on the AL-4 fractional horsepower MicroMotor are features and applications, plus an illustration of Tri-Flux design which increases starting and running torque. Six models range from 1/75 to 1/15 hp. 4 pages. Redmond Co.

*Circle 421 on page 19*

### Diaphragm Valves

Catalog No. 100 on diaphragm valves covers their advantages, applications and specifications. Handwheel, lever and air-operated valves are shown. Valves handle corrosive or hazardous fluids and slurries at temperatures up to 350° F and pressures to 150 psi. 12 pages. Hills-McCanna Co.

*Circle 422 on page 19*

### Vibration Mountings

Engineering and design data, plus a guide to selection are provided in bulletin 702 on "Plate Form and Multiplane Mountings." Used to isolate vibration and shock, mountings are made in ½ to 310-lb capacities. 16 pages. Lord Mfg. Co.

*Circle 423 on page 19*

### Circuit Breakers

Revised bulletin 3411 details the hydraulic-magnetic principle, design, operation and application of general-purpose circuit breakers. Single, two and three-pole breakers are specified. All units will hold 100 per cent rated load. 20 pages. Heinemann Electric Co.

*Circle 434 on page 19*

### Electrical Wiring Devices

Indexed catalog covers expanded line of electrical wiring devices. Shown are fluorescent and incandescent items, cover sockets, industrial terminal blocks and specialties for navy, maritime and aircraft uses. 32 pages. Kulka Electric Mfg. Co.

*Circle 425 on page 19*

### V-Belts

Catalog V-55 describes fractional horsepower, multiple, super strength, steel cable, open end and hexagonal double V-belts for all types of V-drives. Section is also devoted to V-link belting. 24 pages. Maurey Mfg. Corp.

*Circle 426 on page 19*

### Plastic Pipe & Fittings

Information covering technical properties, chemical resistance, sizes, pressures and dimensions, and prices for Ace Riviclor PVC plastic pipe, fittings and valves from ½ to 2 in. is provided in bulletin CE-56. 8 pages. American Hard Rubber Co.

*Circle 427 on page 19*

### Injection Molded Plastics

Injection molding of small nylon and other thermoplastic parts weighing 0.03-oz and only 1¼ in. long, is discussed in bulletin. It covers dimensional and weight limits and illustrates many of the parts that can be molded. 4 pages. Gries Reproducer Corp.

*Circle 428 on page 19*

### Forged Steel Unions

Forged steel unions described in bulletin U-1-56 include 3000-psi types made to AAR specifications; two and four-bolt flange unions in 2000 and 3000-psi classes; 3000-psi O-ring flange unions; as well as orifice, tab orifice, clamp ring, forged stainless steel and lug nut unions. 8 pages. H. K. Porter Co., W-S Fittings Div.

*Circle 429 on page 19*

### Production Brazing

New series of technical articles entitled "Techniques of Metals Joining" published by this company gets under way with illustrated reprint of "Production Brazing" (TIS 2635), a paper delivered to the 1956 meeting of the International Institute of Welding. 9 pages. Eutectic Welding Alloys Corp.

*Circle 430 on page 19*

### Casters

Over 40 new models of casters are described in illustrated catalog 412-A which also lists practical application suggestions and caster selection data. Casters have solid rubber, semipneumatic and full pneumatic wheels in range of capacities. 4 pages. Gleason Corp.

*Circle 431 on page 19*

### Overheat Detectors

Thermistor-actuated overheat detectors for use in aircraft are described in brochure MC-134. Literature discusses advantages of sensing temperature with thermistor elements, suggests applications and installation techniques and lists physical, performance and military specs data. 4 pages. Fenwal Inc.

*Circle 432 on page 19*

### Copying Machines

How diazotype copying machines eliminate up to 90 per cent of the writing in preparing production and assembly orders is told in brochure A-2282. Also explained is the application of mechanical copying in preparation of subassembly and final assembly orders. 8 pages. Charles Bruning Co.

*Circle 433 on page 19*

### Fiber & Plastics

Comparative evaluations of laminated plastic and vulcanized fiber are included in comparator chart. Thirty - four basic grades of fiber and plastics are compared and 23 material property ratings are given

How
DENISON
hydraulic power
works for
Adamson
United

# Precision control for a metal monster

*Denison variable volume axial piston type pump with pressure compensating control, key to this hydraulic system for Adamson United Press.*

● To Denison Engineering went the task of designing accurate, foolproof control equipment for this huge compacting press built by Adamson United, Akron, Ohio. Covering more than 40 square feet of platen area, the press has a 40-inch ram designed to operate on a 2300 psi hydraulic system.

The control system developed by Denison employs a variable-volume axial-piston pump driven by a 15 h.p. motor. A manifold-type hydraulic panel completes the system.

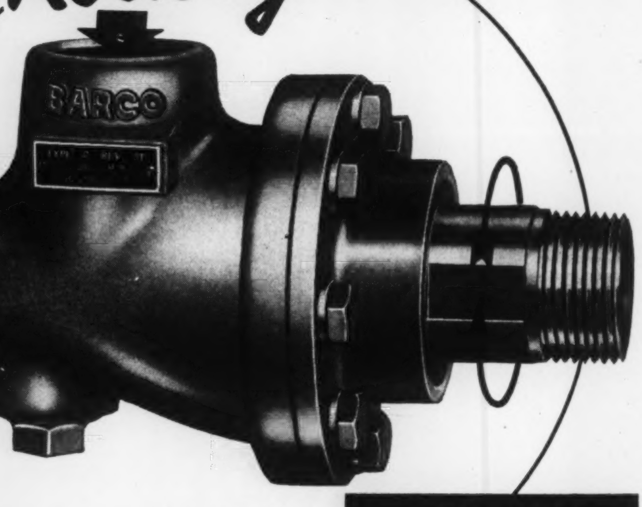
Engineering consulting service like this is available to you at all times to save your design time and assure dependable, efficient performance of your hydraulic circuits. Write us. Denison Engineering Division, American Brake Shoe Co., 1240 Dublin Road, Columbus 16, Ohio.

**DENISON HydrOILics**

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

Circle 581 on page 19

NOW-A Better Rotary Joint!



SIZES
½" ¾" 1" 1¼"
1½" 2" 2½" 3"

NEW
BARCO
TYPE C
Rotary
Joint

Announcing...

*It's new! It's simple! It's versatile!* And for countless applications, Barco's new Type C Rotary Joint will give you the best operating records you've ever had.

**FOR ALL SERVICES**—One basic style of revolving joint for single flow or syphon flow ... one basic seal for steam, air, water, oil, gas — *or alternating hot and cold!* For temperatures to 450°F. Special to 500°F.

**NO LUBRICATION NEEDED** — Bearings and seal self-lubricating. Seal self-adjusting for wear. Long life without repairs or maintenance.

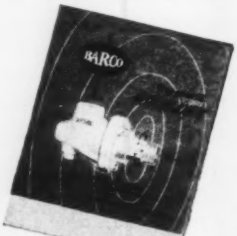
**LOW TORQUE** — Low starting and running torque*. Saves power. Suitable for any ordinary speed. To 200 psi, steam, or 400 psi, hydraulic.

**COMPACT, SIMPLE** — Malleable iron body; heat treated steel shaft; R.H. or L.H. thread. Eight sizes, ½" to 3".

**Typical example: 12 in. lbs. starting torque for 1" Type C on 100 psi water. Rotating torque, same.*

for

STEAM
WATER
OIL
AIR or GAS



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NEW CATALOG 310 TODAY.

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BARCO
PRODUCTS BACKED BY EXPERIENCE

BARCO MANUFACTURING CO.
506N Hough Street • Barrington, Illinois

*The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints*
In Canada: The Holden Co., Ltd., Montreal

Circle 582 on page 19

for each grade. National Vulcanized Fibre Co.

*Circle 434 on page 19*

### Hermetic Compressors

Specification sheets on four hermetic compressors cover 2, 3, 5 and 7½-hp models. Four bulletins list motor and compressor features, dimensions and performance. 2 pages each. Worthington Corp.

*Circle 435 on page 19*

### Plastic Knobs

Standard instrument and control knobs, dials and assemblies illustrated and described in catalog 106 represent a line available from stock. They are produced in any thermosetting plastic material. Dimensional charts are featured. 16 pages. Kurz-Kasch Inc., Standard Parts Div.

*Circle 436 on page 19*

### Time Delay Relays

Details on function of three basic time delay relays in ac, dc and 400-cycle types are found in illustrated bulletin AWH TD403. Time delay ranges are from 1½ seconds to 90 minutes. Wiring diagram, dimensions and other data are included. 2 pages. A. W. Haydon Co.

*Circle 437 on page 19*

### Beryllium Copper Strip

"Heat Treating Curves for Beryllium Copper Strip" is title of bulletin No. 8. It presents heat treat recommendations to produce maximum strength and hardness. Hardness-response curves and specifications are included. 4 pages. Penn Precision Products, Inc.

*Circle 438 on page 19*

### Large Nuts

Illustrated bulletin is devoted to large standard, jam and slotted nuts and line of locknuts. Large nuts are stocked in standard and special hexagon sizes. Specifications are given. 4 pages. Security Locknut Corp.

*Circle 439 on page 19*

### Four-Cycle Engines

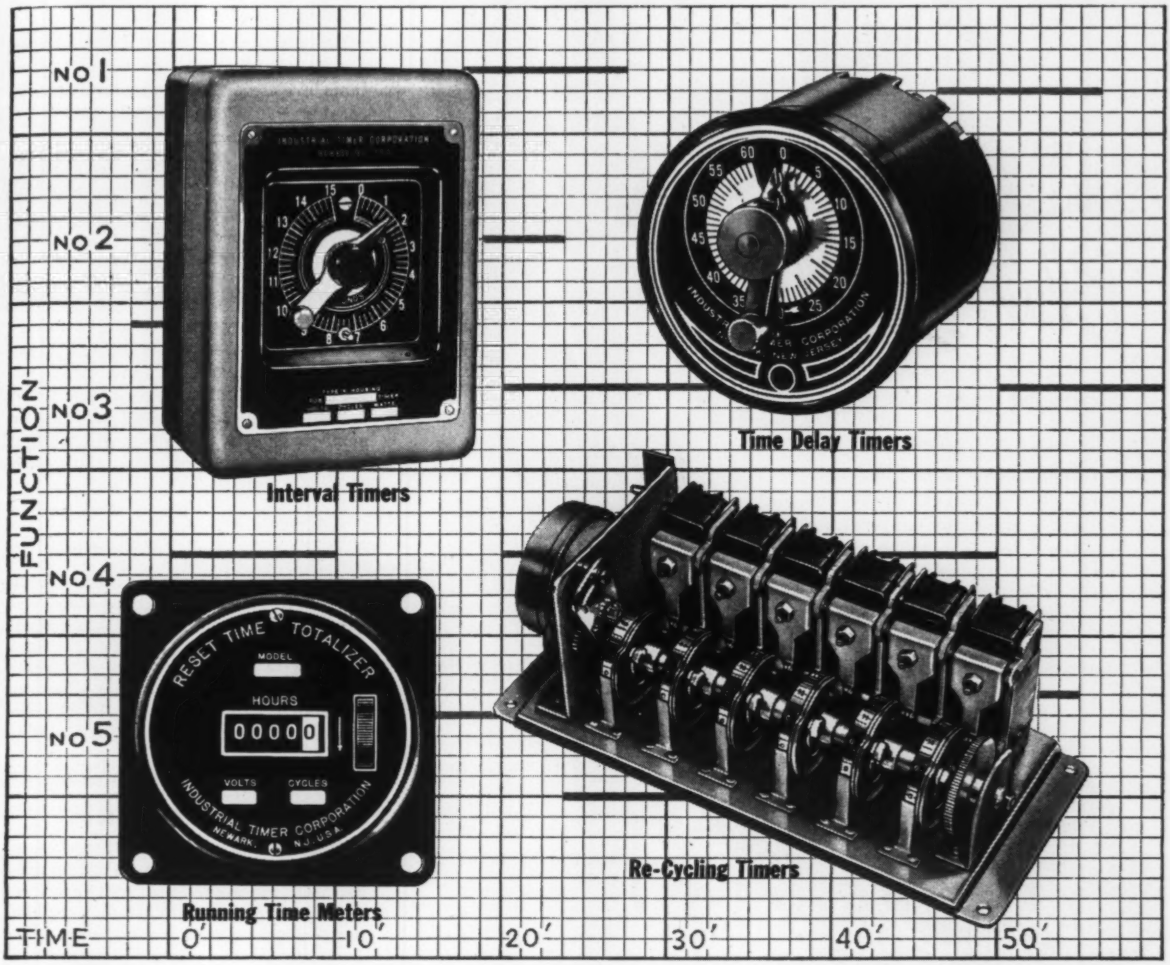
Four short - stroke four - cycle engines, with 1.8, 3.7, 8.2 and 15.0 hp at 1800 rpm, are subject of illustrated folder. Design features, specifications and optional features are described. Dimensional drawings are included. 4 pages. Kohler Co.

*Circle 440 on page 19*

### V-Belt Drives

V-belt drive engineering manual is divided into three sections: V-drive

# YOUR "SPECIAL" TIMER
## *may be one of our*
# 721 STANDARD UNITS!


NO 1
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NO 5
FUNCTION
Interval Timers
Time Delay Timers
Re-Cycling Timers
Running Time Meters
RESET TIME TOTALIZER
HOURS
00000
VOLTS
CYCLES
INDUSTRIAL TIMER CORPORATION
NEWARK, N.J. U.S.A.
TIME
0'
10'
20'
30'
40'
50'

**We** have 20 years of experience in developing new timers to meet our customers' widely varying requirements. Our Engineering Department not only originates new designs, but also develops modifications for that purpose. That's why most requests for special timers can be filled without delay—by one of the 721 combinations we've developed so far from our 17 basic types of timers. But if we don't have what you want on hand, we'll welcome the chance to design and make it for you! And quickly too!

We manufacture a complete line of timers in these 4 broad classifications:

**INTERVAL TIMERS • TIME DELAY TIMERS**
**RE-CYCLING TIMERS • RUNNING TIME METERS**

Our large stock assures you of rapid deliveries—even when we have to create a brand new timer for your special needs. Ask us first—you may save yourself much lost motion . . . and your inquiry will receive prompt attention.

*Timers that Control*
*the Pulse Beat of Industry*

**INDUSTRIAL TIMER CORPORATION**
1413 McCARTER HIGHWAY, NEWARK 4, N. J.

*Circle 583 on page 19*

Socket Set Screws
Socket Cap Screws
Flat Head Cap Screws
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shows how cold forming of Blue Devil Socket head insures unimpaired fiber continuity.

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Warehouses at: Los Angeles • San Francisco • Detroit • New Haven, Conn.

Socket Screws Exclusively!

*Circle 584 on page 19*

selection, drive design and general information. Covered are determining required horsepower, belt speed, number of belts required and the right belt length. Much data are in table form. 66 pages. Maurey Mfg. Corp.

*Circle 441 on page 19*

### Standard Metal Shapes

Die formed standard metal shapes adaptable to various mechanical functions are described and illustrated in catalog P3. Code analysis and index system provides an easy method of identifying 24 different shapes. Tabular data on each is given. 24 pages. Commercial Shearing & Stamping Co.

*Circle 442 on page 19*

### Stainless Steel Sleeves

Centrifugally cast stainless steel sleeves, annealed for maximum machinability, corrosion and heat resistance, are available in standard cored bar stock sizes, as-cast or semi-machined. Properties, nominal strengths and available sizes are given. 4 pages. Vollrath Co.

*Circle 443 on page 19*

### High Temperature Lubrication

Brief case histories in illustrated brochure 423 describe how 'dag' colloidal graphite, a high purity graphite dispersed in a variety of fluid carriers, is used for general high temperature lubrication application. Methods of increasing die life are described. 8 pages. Acheson Colloids Co.

*Circle 444 on page 19*

### General Purpose Controls

General purpose control operation and application manual describes manual, magnetic and reduced voltage starters, pushbuttons, relays, limit switches, solenoids, and pressure and vacuum, float, plugging and antiplugging switches. Application data are included. 32 pages. General Electric Co.

*Circle 445 on page 19*

### Bearings & Rod End Bearings

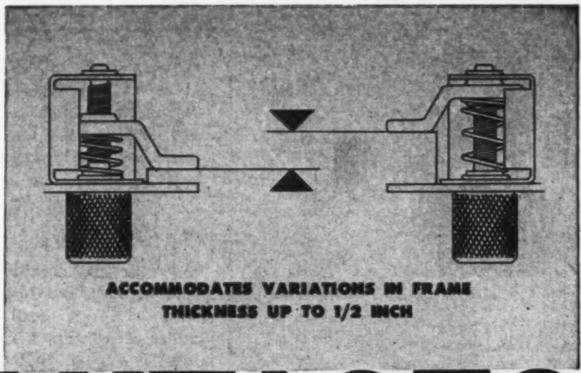
Spiral bound and illustrated catalog 551 on self-aligning bearings and rod end bearings contains dimensional drawings and complete specifications for entire line of these products. Service instructions are included. 42 pages. Southwest Products Co.

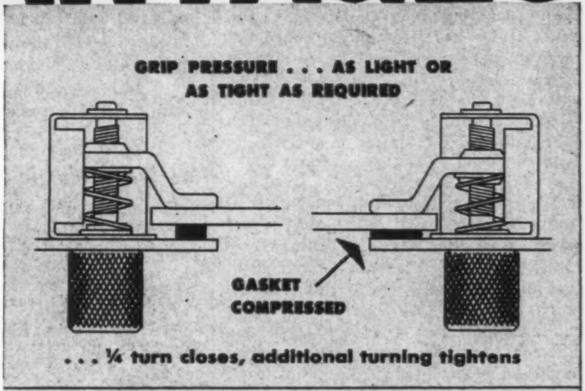
*Circle 446 on page 19*

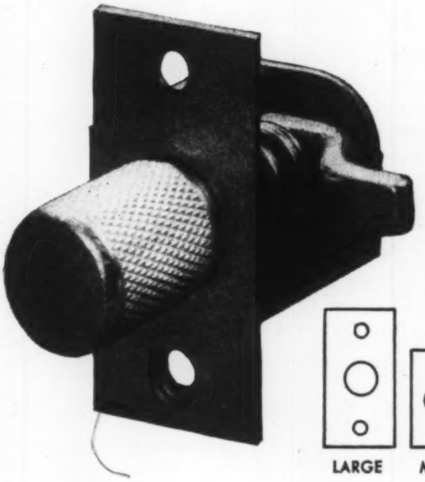
### Pressure Sensitive Tapes

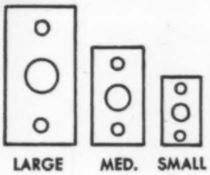
Multitude of ways to use tapes is disclosed in illustrated handbook. A a family of door fasteners with

# BIG ADVANTAGES


ACCOMMODATES VARIATIONS IN FRAME THICKNESS UP TO 1/2 INCH


GRIP PRESSURE . . . AS LIGHT OR AS TIGHT AS REQUIRED
GASKET COMPRESSED
. . . ¼ turn closes, additional turning tightens




LARGE
MED.
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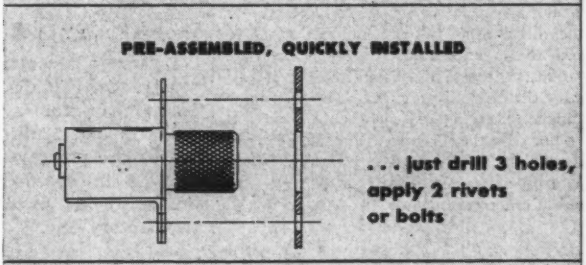
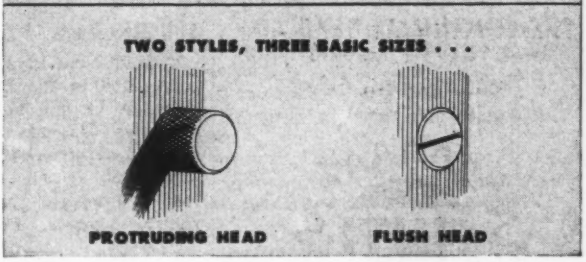

PRE-ASSEMBLED, QUICKLY INSTALLED
. . . just drill 3 holes, apply 2 rivets or bolts


TWO STYLES, THREE BASIC SIZES . . .
PROTRUDING HEAD
FLUSH HEAD

Get the complete story of Southco Pawl Fastener advantages. Write today for your copy of the Southco Fastener Handbook. Southco Division, South Chester Corporation. 237 Industrial Highway, Lester, Pa.

**SOUTHCO FASTENERS**

**LION**

©1956

Circle 585 on page 19

57 VARIETIES boiled down

L. A. Edwards

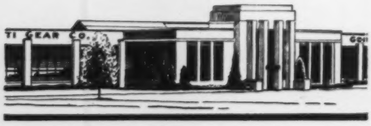
ASST. SALES MGR., THE CINCINNATI GEAR CO.

We could pass ourselves off as the Heinz of the Gear Industry by naming at least 57 different varieties of gears that we manufacture — but to be more concise, the gears we produce can be listed in eleven *basic* categories: spur, helical, rack, worm, herringbone, bevel, spiral bevel, internal, sprocket, Zerol* and Coniflex* (*Reg. U.S. Pat. Off.). This is still a pretty impressive list, we think, and covers just about all types in current demand for industrial use. Of course there are many variations within these basic types, too — such as a hypoid gear, which is basically a spiral bevel gear.

If you're one who has always thought that "gears is just gears," it will pay you to find out just what advantages each of these types has to offer. For instance, a straight bevel gear might perform *adequately* in an application that *ideally* calls for a Zerol gear; but fine points such as this can make the difference between *adequate* and *superior* results from your product. Your Cincinnati Gear Representative can cite advantages for the different gear types, and perhaps give you some ideas for applications in your products that you may have overlooked. And after the "right" gear has been chosen for your application, we can produce it for you — not only the right *kind* of gear, but with the "right" *quality* and *service* to assure your becoming another of our many satisfied repeat-order customers.

**THE CINCINNATI GEAR CO.**
CINCINNATI 27, OHIO
*"Gears—Good Gears Only"*

CINTI ®



Circle 586 on page 19

## Helpful Literature

"tape finder," aids in tape selection. Covered are masking, nonstaining, waterproof, high temperature, packaging, printable and other tapes and adhesives. 68 pages. Mystik Adhesive Products, Inc.

*Circle 447 on page 19*

### Electric Motors

Protection against chemical corrosion, localized hot-spots and abrasive wear is built into Linc-Weld motors, described in illustrated bulletin SB-1345. All coils are hermetically sealed in thermosetting plastic. Design features and specs are given. 4 pages. Lincoln Electric Co.

*Circle 448 on page 19*

### Lubricating Equipment

Modern lubricating equipment illustrated and briefly described in bulletin X-125 include oil cups, oiling systems, dispensers, valves and flow sights, liquid level gages and chain oilers. 4 pages. Oil-Rite Corp.

*Circle 449 on page 19*

### Machined Plastic Parts

Examples of parts machined from Plexiglas, Micarta, nylon, Teflon, fiber, Celeron, Formica and other plastics are shown in illustrated folder. Company's production facilities are outlined. 4 pages. Engineered Plastics, Inc.

*Circle 450 on page 19*

### Speed Reducers & Gearmotors

Design modifications as well as construction details of line of Slo-Speed gear motors, Slo-Speed motor reducers and Multi-Mount speed reducers are portrayed in bulletin 191. Factors in speed reducer selection are listed. 12 pages. Sterling Electric Motors, Inc.

*Circle 451 on page 19*

### Ball Bearings

Contact-type Plya-Seal as now incorporated in the Fafnir wide inner ring line of ball bearings keeps out excessive amounts of contaminants even at slow speeds, while retaining supply of grease. Dimensions and load ratings are given in descriptive folder. 6 pages. Fafnir Bearing Co.

*Circle 452 on page 19*

### Wrought Washers

All sizes of light steel washers, machinery bushings and expansion plugs, as well as AN, bevel, square, brass, narrow rim, special, countersunk finishing carburized and spring tension washers are listed in catalog 40. Wrought Washer Mfg. Co., 2100 S. Bay St., Milwaukee 7, Wis.

IF

PRECISION MANUFACTURING IS YOUR REQUIREMENT

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Boehme practical experience
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*Designers and Manufacturers*
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*Apparatus Since 1917*
915 Broadway
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HOB

Circle 587 on page 19

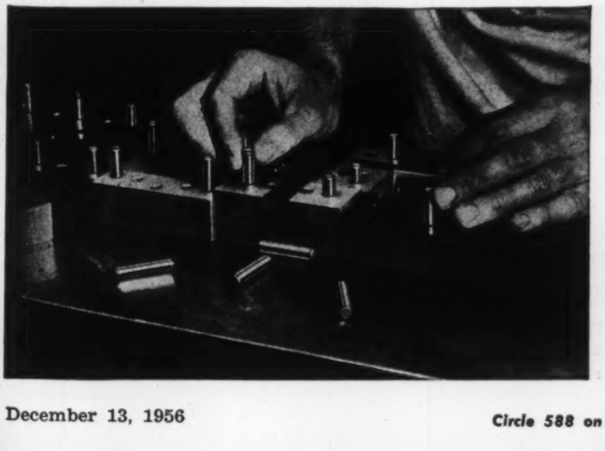
## "STOCK ANSWER"
## to many a design problem

# ALLEN DOWEL PINS

**ALLEN DOWEL PINS** are being profitably employed in a thousand and one ingenious ways beyond their conventional applications in tool and die work — as economical roller bearings, as axles, precision plugs, hinges and wrist pins to name a few.

If you have an application that will utilize the great strength, accuracy and fine finish of Allen Dowel Pins, you can save substantially on the cost of your product — because you can secure them at favorable prices right from your Allen Distributor's stock.

Check the quick facts at the right and write directly to Allen's Engineering Department for further technical information.



### SPECIFICATIONS

- Made from Allenoy heat treated steel. Surface hardness 62-64, Rockwell C scale; core hardness 52-54. Case depth .010" to .020" depending on size.
- Single shear strength 160,000 to 180,000 p.s.i.
- Surfaces precision ground to ± .0001" with micro-inch finish of 6 RMS max.
- Sizes: Diameters, ⅛" to 1". Lengths, ⅜" to 6".
- Two standard oversizes — .0002 for press fits between mating parts, or .001 for repair work, or holes machined oversize.

ALLEN

ALLEN HEAD

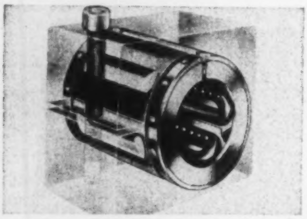
Circle 588 on page 19

# New Parts and Materials

Use Yellow Card, page 19, to obtain more information

## Ball Bushing

### is adjustable for wear or shaft size

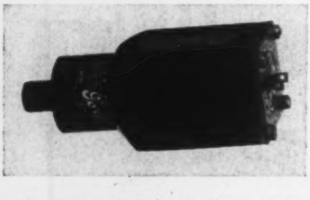


Adjustable diameter ball bushing is split longitudinally and designed to provide line-to-line or slight preload fits when mounted in split housings. Construction eliminates need for selective assembly normally required to obtain no-clearance fits because of tolerances on housing bore, bearing bore and shaft diameter. Design also permits compensation for wear which may develop in severe applications. Unit is available in standard bore sizes from 1 to 3 in. **Thomas Industries Inc.,** Manhasset, N. Y.

*Circle 453 on page 19*

## Vacuum Pressure Switch

### withstands high vibratory conditions

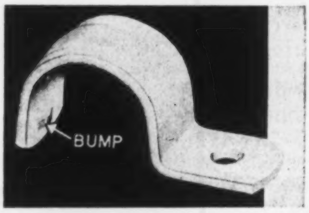


Vacuum pressure switch maintains fault-free performance under environmental conditions encountered in aircraft and missile systems. Switch responds to pressures as low as 2 in. Hg absolute, retains accuracy to ±1 in. pressure under extreme environmental conditions and has a rigid miniature bellows supported to resist self-actuation under vibration up to 2000 cps at 10 g. Switch is available in models for use in inert-gas vacuum, fluid vacuum and absolute pressure. Weight is less than 3 oz; length is 3½ in. **Gorn Electric Co., Gorn Aircraft Controls Co.,** 845 Main St., Stamford, Conn.

*Circle 454 on page 19*

## Pipe Strap

### snaps onto pipe, speeding assembly

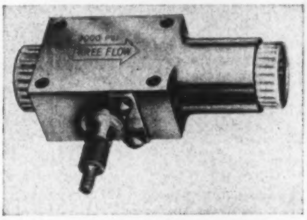


Snap-on strap for pipe, cable, and conduit snaps on, leaving assembler's hands free. Detent inside strap causes strap to spring slightly when assembled and holds it in place during assembly or installation operations. Straps are of heavy gage zinc-plated steel, in sizes for ½-in. through 2 in. thin wall conduit and ⅜-in. through 2 in. pipe. **Holub Industries Inc.,** Sycamore, Ill.

*Circle 455 on page 19*

## Check Valves

### for heavy-duty use at 3000 psi pressure

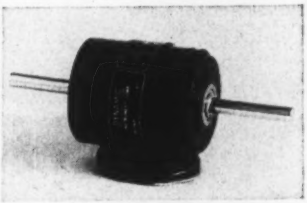


Rotary-type controllable check valves, designated Series 5900, are available in three styles for tubing sizes of ¼, ½ and ¾-in. OD. Designed for heavy-duty applications at 3000 psi pressure, they can also be used as shut-offs for piping gasoline and lubricating oil, and for zero-leakage sequence operation. The valves, which have an aluminum alloy housing and stainless-steel internal parts, have no leakage at 3000 psi and 1 drop per minute at 5 psi. Liquid temperatures from 65 to 160 F can be handled. Valves weigh from 0.37 to 0.87-lb and have handle torques from 45 to 90 in.-lb. They conform to MS-28880 and exceed MIL-V-5528. **Aircraft Products Co.,** Tactair Valve Div., 300 Church Rd., Bridgeport, Pa.

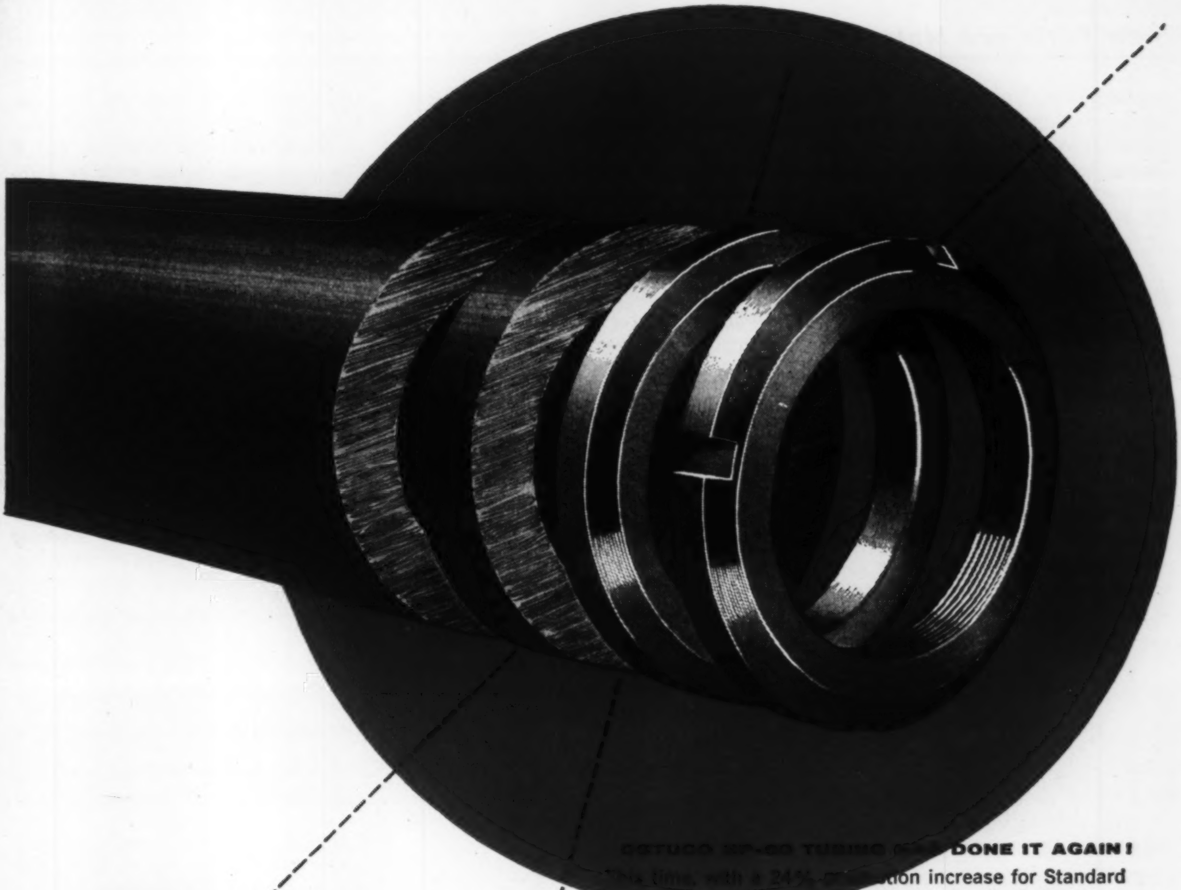
*Circle 456 on page 19*

## Friction Clutch

### delivers minimum of 50 oz-in. torque



Magnetic friction clutch which meets military environmental and performance specifications has application in low-power servomechanisms. It operates on 24 v dc, delivering a minimum of 50 oz-in. torque. Response time is within 3



**OSTUCO NP-60 TUBING HAS DONE IT AGAIN!**

This time, with a 24% production increase for Standard Locknut and Lockwasher, Inc., Indianapolis, Indiana. Tubing experts from OSTUCO recently recommended a switch to NP-60 Tubing specially processed for machineability for Standard's locknut and lockwasher line used in ball and roller bearing applications.

Standard components find their way into electric motors, machine tools, automotive, aircraft, farm and construction equipment. Other companies, with equally diverse applications, report similar success with NP-60. If you are machining bearings, washers, collars, or any circular part, you'll do well to check into the merits of OSTUCO's new NP-60 seamless steel tubing.

## *24% Production increase at Standard Locknut & Lockwasher, Inc. after switching to OSTUCO NP-60 tubing*

**GET NP-60 WITH "SINGLE-SOURCE SERVICE."**

New NP-60 seamless tubing comes to you with OSTUCO'S unique "Single-Source Service"—experience and facilities for design and development, production and delivery all under one roof. Get together with a tubing expert for preliminary planning on NP-60's possibilities in your product. Contact your nearest sales office or write direct to the factory.

OSTUCO
SHELBY, OHIO

# OSTUCO TUBING

SEAMLESS AND ELECTRIC RESISTANCE
WELDED STEEL TUBING—*Fabricating and Forging*

***OHIO SEAMLESS TUBE DIVISION***
*of Copperweld Steel Company* • ***SHELBY, OHIO***
***Birthplace of the Seamless Steel Tube Industry in America***

***SALES OFFICES:*** *BIRMINGHAM • CHARLOTTE • CHICAGO (Oak Park)*
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*NEW YORK • NORTH KANSAS CITY • PHILADELPHIA*
*PITTSBURGH • RICHMOND • ROCHESTER • ST. LOUIS*
*ST. PAUL • SALT LAKE CITY • SEATTLE • TULSA • WICHITA*
***CANADA,*** *RAILWAY & POWER ENGR. CORP., LTD.*
***EXPORT:*** *COPPERWELD STEEL INTERNATIONAL COMPANY*
*225 Broadway, New York 7, New York*

*Circle 589 on page 19*

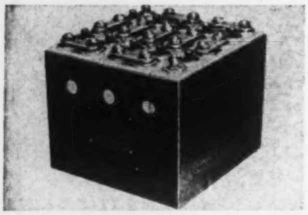
milliseconds. Unit introduces 2 minutes maximum angular displacement error into the system upon engagement. Power consumption is 3 w. **Dynamic Instrument Corp.,** 59 New York Ave., Westbury, L.I., N. Y.

*Circle 457 on page 19*

## Nickel-Cadmium Batteries

**miniaturized units from ½ to 150 amp-hr**

Miniaturized nickel-cadmium sintered plate storage batteries have capacities from ½ to over 150 amp-hr and provide high cranking currents for engine starting in off-highway vehicles and other heavy motorized equipment. Batteries deliver momentary discharge currents as high as 25 times rated amp-hr capacity. Capable of repeated cycle service, units have a temperature range from −40 to 165 F. Units require little maintenance and may be stored indefinitely in any state of charge without deterioration or danger of freezing. Corrosive fumes are not emitted, and pressure release plugs prevent electrolyte spillage. **Nickel Cadmium Battery Corp.,** 68 Pleasant St., Easthampton, Mass.



*Circle 458 on page 19*

## Prefinished Metals

**have clear synthetic protective coating**

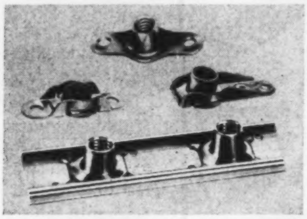
Baked synthetic protective coating for Nickeloid prefinished metals in copper and brass finishes contains a thermosetting resin with excellent film properties. In 48-hour salt spray tests using preplated copper steel, film showed 80 to 90 per cent better resistance than ordinary lacquer. Film is baked and cured under high heat to provide a tough, adherent elastic film which provides maximum gloss, flexibility, chemical and abrasion resistance. Metals coated with the film can be drawn, stamped, roll formed and seamed without peeling, cracking or flaking of the film. Applications are door hardware, switch plates, light fixtures, housewares, and other functional and decorative purposes where a protected copper or brass finish is necessary. **American Nickeloid Co.,** 14 Second St., Peru, Ill.

*Circle 459 on page 19*

## Self-Locking Fasteners

**meet requirements of NAS 680-695 drawings**

Reduced height, counterbored, self-locking anchor and gang channel nuts are designed with minimum envelope dimensions compatible with performance requirements for structural aircraft applications. Having reduced width and weight, LHTA Series fasteners develop full tensile, vibration, twist-out and push-up requirements of MIL-N-25027 (ASG). The heat-treated carbon steel fasteners perform satisfactorily at temperatures to 550 F. They are approved to AN-N-10, drawings AN 362 and AN 366, and meet the requirements of the new NAS 680-695 drawings. Current thread sizes are 8-32, 10-32, ¼-28 and 5/16-24. **Elastic Stop Nut Corp. of America,** 2330 Vauxhall Rd., Union, N. J.

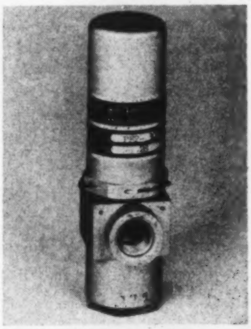


*Circle 460 on page 19*

## Pressure Reducer

**regulates pressures to 3000 psi**

Small, lightweight pneumatic pressure reducer is available in ¼ and ⅜-in. tube sizes. It is completely balanced, producing straight line regulation, with leaktight shut-off, rated capacity of 3000 psi and small initial pressure drop under flow conditions. Normal temperature range is −65 to 225 F The unit is furnished with or without a built-in relief valve. Reducer weighs from 0.4 to 0.6-lb, and conforms to MIL-R-8572A. **Pneu-Hydro Valve Corp.,** 364 Glenwood Ave., East Orange, N. J.



*Circle 461 on page 19*

## Liquid Sealant

**for production locking of threaded fasteners**

Locktite sealant automatically hardens between mating metal surfaces, eliminating the need for lock washers and lock nuts. Sealant holds fasteners in any position on the threaded length, does not score threads, and seals the seating surfaces against dirt, corrosion and fluid pressure. It is available in a 50 cc plastic bottle, primarily intended for multiple application by tumbling, brushing or dipping. An applicator nozzle is supplied for individual application. Sealant can be stored safely in the plastic bottle for extended periods of time. **American Sealants Co.,** Hartford, Conn.

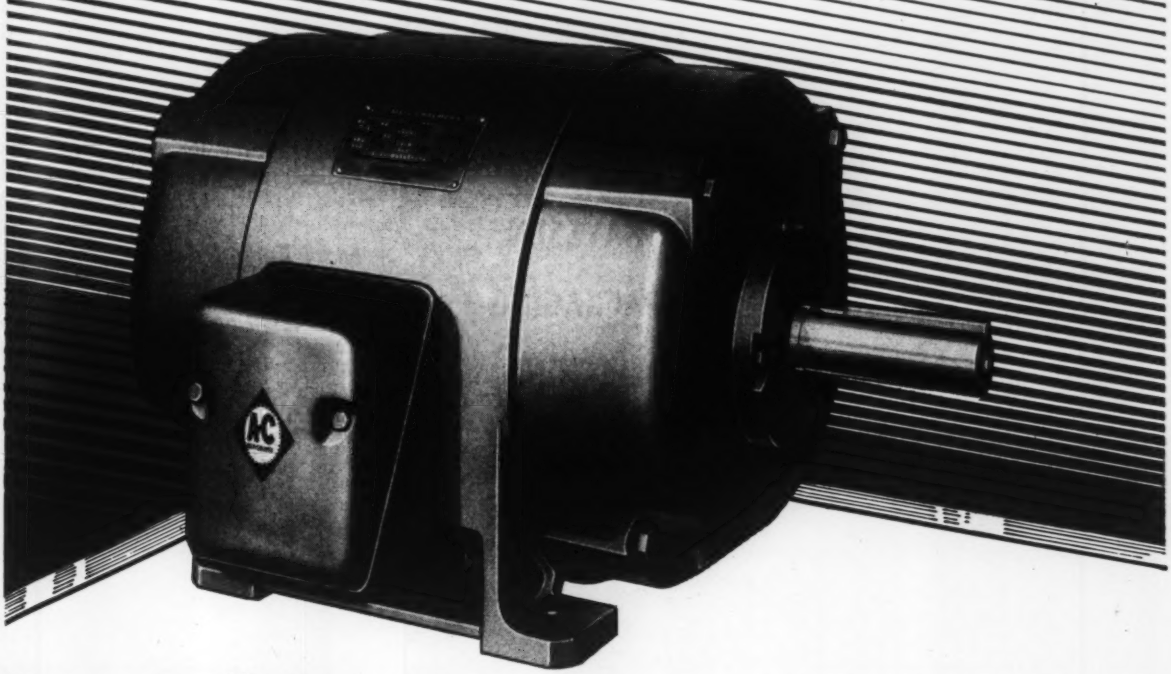
*Circle 462 on page 19*

## Sintered-Brass Nuts

**have tensile strengths to 35,000 psi**

These sintered-brass hex nuts are made to any desired shape, to very close tolerances, and with tensile strengths of 30,000 to 35,000 psi. They are available in widths from 5/32 to 9/16-in. and thicknesses from 3/64 to 19/64-in., in a wide range of hole and thread sizes. The nuts are finished in bright brass,

# NEW *Synduction* MOTOR



## Do you have an Application Requiring . . .

- **. . . Constant speed, regardless of load or voltage, depending only on frequency.**
- **. . . Synchronized speed for a number of motors.**
- **. . . Adjustable speed with minimum variation at any speed setting.**

## Synchronous Speed with Induction Simplicity

Allis-Chalmers new development — the *Synduction* motor — offers these characteristics at low cost — with the dependability of an induction motor. In addition to constant speed from no load to pull-out, it also offers across-the-line starting, wide range of speeds and high efficiency. It's another example of MORE motor pioneering by Allis-Chalmers.

Allis-Chalmers invites your inquiry, in the belief that many processes can be improved by the application of *Synduction* motors. Our engineers will gladly analyze your present operations to help you determine where *Synduction* motors can be applied profitably. Call your A-C office or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin, for Bulletin 51B8440.

*Synduction* is an Allis-Chalmers trademark.

A-C ALLIS-CHALMERS

**ALLIS-CHALMERS**

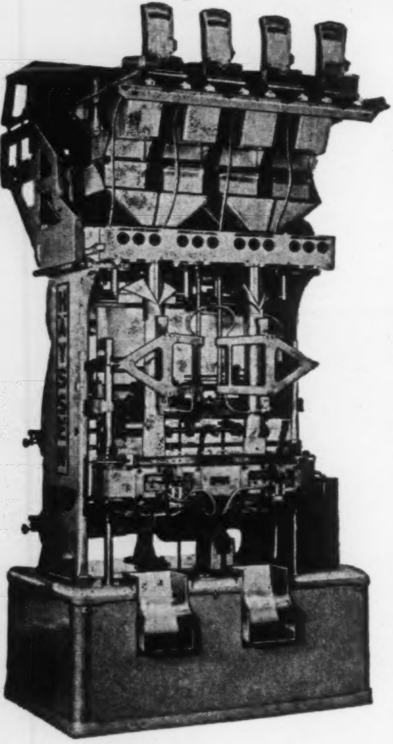
A-5115

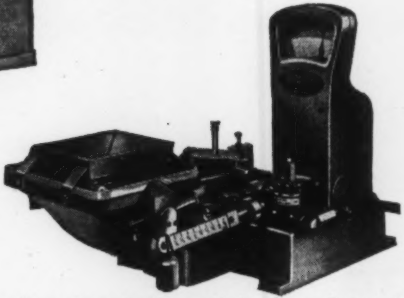
*Circle 590 on page 19*

ONE MORE EXAMPLE of how EXACT WEIGHT Scales are being used in modern machinery design

NOW

EXACT WEIGHT SCALES CONTROL ACCURACY IN HAYSSEN PACKAGING MACHINE





Model 610
Net Weigher*

The EXACT WEIGHT Scales, incorporated as original equipment in the Hayssen Model "F" Compak Automatic Packaging Machine, control each filling operation with accuracy heretofore unattainable.

Weigh Feeders, developed by EXACT WEIGHT as original equipment for HPM Plastics Injection Molding Machines, provide more accurate measurement than is possible with volumetric feed.

EXACT WEIGHT Scales are now successfully used on milling machines to automatically weigh, balance, pre-set the machine and check the finished product.

EXACT WEIGHT Scales can be easily incorporated into the design of any machine that requires accurately controlled weight as part of its function.

Complete engineering data is available to designers. Write for free form #3305 to help you do a better job.

*The Net Weigher, shown above, is designed for original equipment installation. Write for complete details.

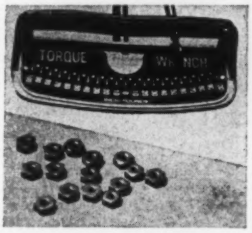
There is no substitute for Exact Weight

Exact Weight Scales
Better quality control
Better cost control

THE EXACT WEIGHT SCALE COMPANY
923 W. Fifth Avenue, Columbus 8, Ohio
In Canada: P.O. Box 179, Station S, Toronto 18, Ont.

Circle 591 on page 19

cadmium, zinc or nickel plating, or black oxide. They compare favorably in detail, dimensional control and mechanical properties with conventional brass nuts. **Midwest Sintered Products Corp.,** 13605 S. Halsted St., Chicago 27, Ill.



*Circle 463 on page 19*

## Foam Polyethylene

### for insulation or sound absorption

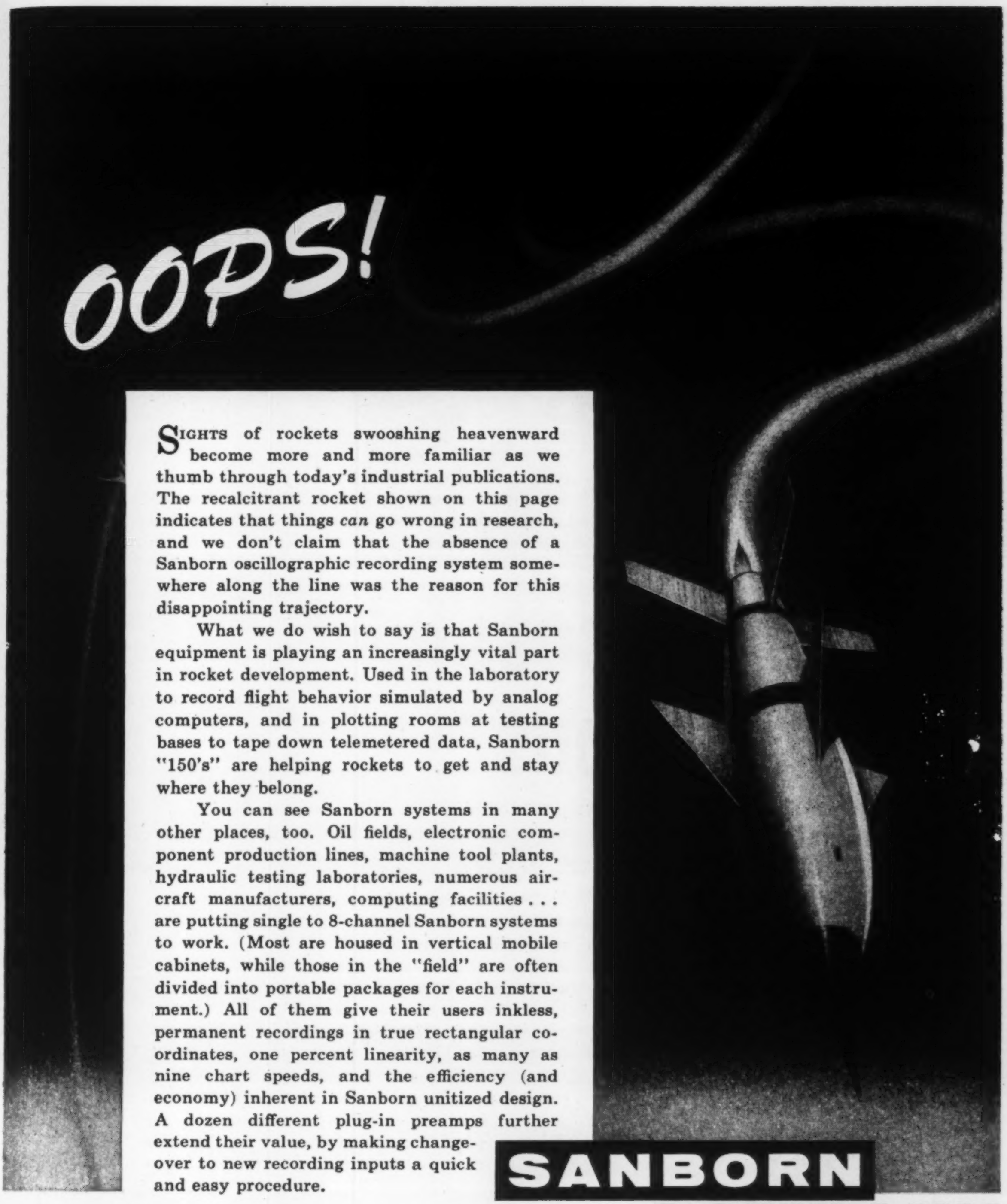
Expanded foam polyethylene known as Agilene-F, is available in semifinished molded shapes such as rings, blocks, rods, and sheet. Material may be used for heat and electrical insulation, soundproofing, and similar applications. Specific gravity is 0.46 (or 0.33 if desired). Material is unicellular, very light in weight, extremely buoyant, readily compressed, and has tensile strength of 500 to 600 psi. **American Agile Corp.,** P. O. Box 168, Bedford, O.

*Circle 464 on page 19*

## Check Valve

### has protected O-ring seal

Protected-type 3000 psi stainless steel check valve has protected O-ring seal on valve poppet. Since the O-ring is protected from damage by flow turbulence or erosion, it may be any of a broad selection of synthetic materials. For example, low tensile strength silicone can be furnished for temper-

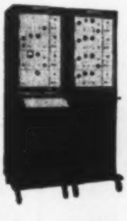


Sights of rockets swooshing heavenward become more and more familiar as we thumb through today's industrial publications. The recalcitrant rocket shown on this page indicates that things *can* go wrong in research, and we don't claim that the absence of a Sanborn oscillographic recording system somewhere along the line was the reason for this disappointing trajectory.

What we do wish to say is that Sanborn equipment is playing an increasingly vital part in rocket development. Used in the laboratory to record flight behavior simulated by analog computers, and in plotting rooms at testing bases to tape down telemetered data, Sanborn "150's" are helping rockets to get and stay where they belong.

You can see Sanborn systems in many other places, too. Oil fields, electronic component production lines, machine tool plants, hydraulic testing laboratories, numerous aircraft manufacturers, computing facilities . . . are putting single to 8-channel Sanborn systems to work. (Most are housed in vertical mobile cabinets, while those in the "field" are often divided into portable packages for each instrument.) All of them give their users inkless, permanent recordings in true rectangular coordinates, one percent linearity, as many as nine chart speeds, and the efficiency (and economy) inherent in Sanborn unitized design. A dozen different plug-in preamps further extend their value, by making changeover to new recording inputs a quick and easy procedure.

**SANBORN COMPANY**
CAMBRIDGE 39, MASSACHUSETTS


**8-, 6-CHANNEL**

**4-CHANNEL**

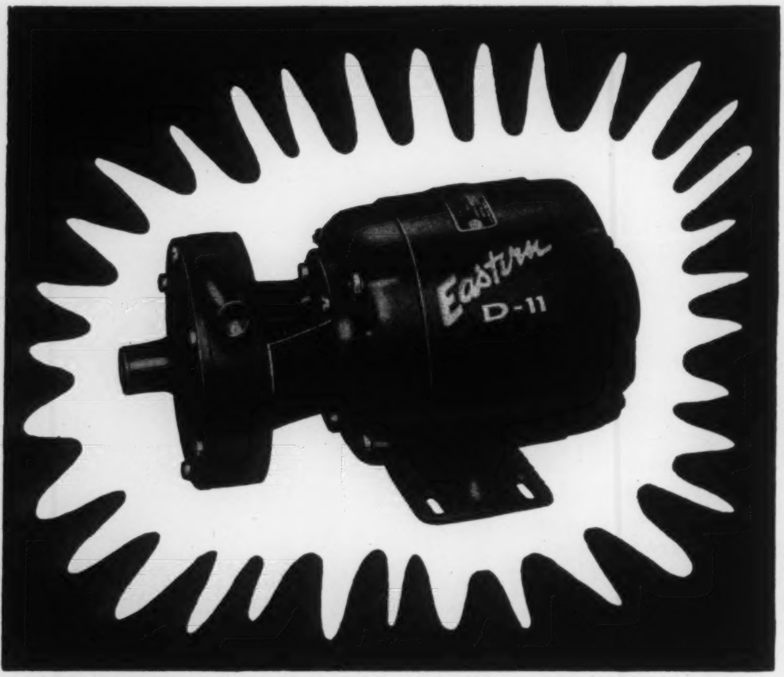
**2-CHANNEL**

**1-CHANNEL**

**2-, 4-, 6-, 8-CHANNEL**
**ANALOG COMPUTER SYSTEMS**

**Which way rockets are going may not be a primary concern of yours. But if recording problems *are*, you're apt to find some interesting and useful answers in Sanborn's 16 page "150 System" catalog. Write to us for a copy.**

*Circle 592 on page 19*



24,830 successful installations!

EASTERN D-11 CENTRIFUGAL PUMP

Why is the D-11 so successful among original equipment manufacturers? *Size and weight* make it ideal. The D-11 is the smallest, close-coupled, single-stage centrifugal pump available with an induction type motor. Eighteen pounds of compact design (9¾″ x 4⅝″) make it excel in industrial and process equipment, as well as laboratory service, and pilot plant operations.

SPECIAL METALS

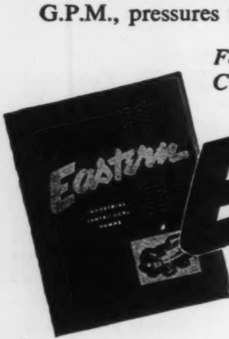
A full selection of metals make the D-11 and other Eastern Centrifugal Pumps versatile performers. Available in 18-8 Type 303 and Type 316 Stainless Steel, Monel, Hastelloy "C", Cast Iron and Bronze, Eastern Pumps range from ⅛th to ¾ H.P. with capacities up to 70 G.P.M., pressures to 65 P.S.I.

*For complete specifications on all Eastern Centrifugal Pumps, request Bulletin 120-G*

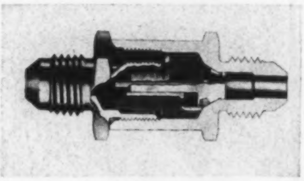
Eastern

INDUSTRIES, INC.
100 Skiff St., Hamden 14, Conn.

Circle 593 on page 19



atures to 450 F; special seals can be furnished for red fuming nitric acid. Tube sizes are ¼, ⅜, and ½-in. in two types: one for 37-deg flared tube fittings, the other for Ermeto-type fittings. **Mansfield & Green,** 1051 Power Ave., Cleveland 14, Ohio.

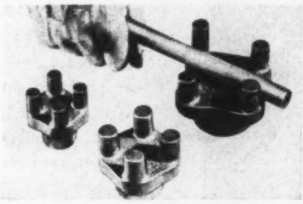


*Circle 465 on page 19*

## Bar Knobs

**provide heavy-duty handles for clamping**

Four-pronged speed bar knobs are durable malleable iron and are easily turned by hand or with a bar or handle inserted between the prongs. Four models have extra length prong for use with crank handle. Range of 15 threaded models provides sizes for all requirements. Knobs are for hold-down clamps, dogs, and cranks and handles on machine tools. **Jergens Tool Specialty Co.,** 712 E. 163rd St., Cleveland 10, Ohio.



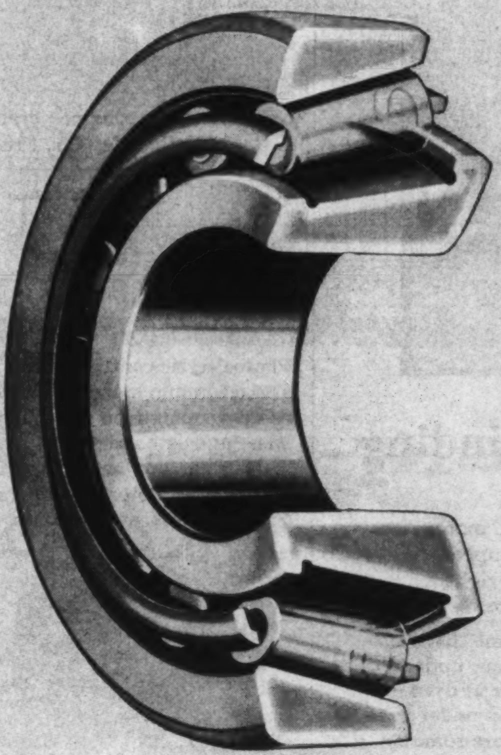
*Circle 466 on page 19*

## Reverse-Reduction Unit

**for use with 5 hp gasoline engines**

Complete power control of gasoline engines is provided by this reverse-reduction unit, which incorporates a 2:1 reduction, definite neutral, positive forward and reverse. Double-acting precision clutch with over-center shift mechanism permits instant shifting from forward to reverse or neutral at any engine speed. Forward rotation is accomplished through a roller chain drive, reverse rotation

# There's a BOWER TAPERED ROLLER BEARING engineered to fit your product



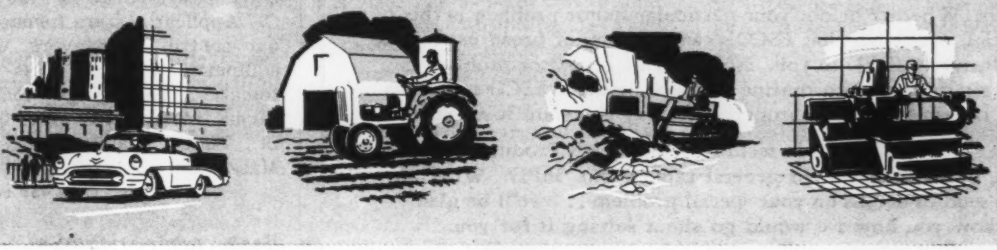
## Types and sizes to fit a wide range of tapered bearing applications

There's no need to compromise with bearings! Whatever your product, if it uses tapered roller bearings, call in a Bower engineer for expert help on selecting the exact type and size you need.

Depending on your own particular needs, he'll make sure you get the exact size and type—selected from Bower's complete tapered line—engineered to assure maximum performance in your application.

Most important of all, when you specify Bower tapered roller bearings for your product, you get all the advantages of advanced Spher-O-Honed design—less maintenance, longer life, smoother operation. Get the full facts on the *complete* Bower line.

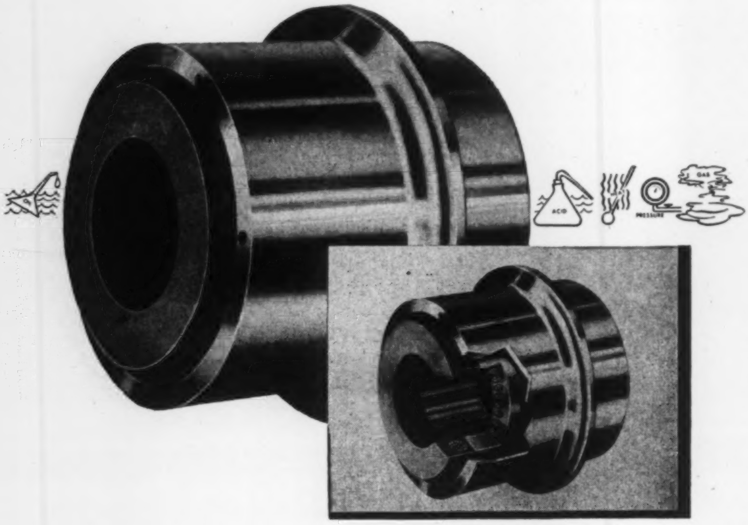
**Tapered, Straight and Journal Roller Bearings for every field of transportation and industry**



BOWER ROLLER BEARINGS

*BOWER ROLLER BEARING DIVISION* • *FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICH.*

SPECIAL



nothing can touch this winding

Oil, acid, vapor, heat and pressure don't affect this AC motor winding. It's completely encased in a special, high-temperature, chemical-resistant plastic. The windings are cast right in the plastic to make a single, solid, impervious piece.

Of course, this winding goes into a special motor — one that's designed to run in a pressurized atmosphere of inert gas, under constant exposure to a piping-hot oil splash and vapor at over 200°F. Temperature-stabilized bearings, oil lubricated under pressure, and drip-proof, corrosion-resistant construction are some other design necessities for this unique 115-volt, 1/3 hp AC motor.

Here is a typical example of ESCO's unusual ability to design and build rotary electrical equipment to meet special customer needs. Whether or not your particular motor problem is this special, remember that ESCO's twenty years of broad experience is always available to you. No motor or generator problem is too big or small, too routine or specialized for ESCO engineers and craftsmen to solve properly, the way you want it solved.

Refer to Esco Catalog in section $\frac{4a}{El}$ in Sweet's Product Design File, or write direct for general catalog No. 56PD. Why not also send us details on your special problem . . . we'll be glad to show you how we would go about solving it for you.

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

Circle 595 on page 19

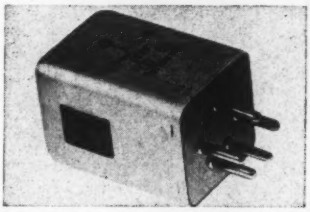
through spur gears. The unit, designed for use with 5-hp, 3600-rpm engines, is fully enclosed and can be bolted to engine crankcase. **J. B. Foote Foundry Co.,** Fredericktown, O.

Circle 467 on page 19

## Photoelectric Control

### operates at 5 ft-c or less

Photoelectric control utilizes broad-area cadmium sulfide photocell and relay, mounted on a 5-pin plug-in base and housed in a dust can measuring 1½ in. square by 2¼ in. high. Photorelay operates at 5 ft-c or less and releases at 0.1-ft-c or more at a speed of two operations per second. Supply voltage is 115 v ac, 50/60 cycles, and temperature range is −40 to +75 C. Applications are furnace flame-out controls, conveyors, weighing equipment, machine tools and automatic packaging machinery. **Sigma Instruments Inc.,** 59 Pearl St., South Braintree, Boston 85, Mass.

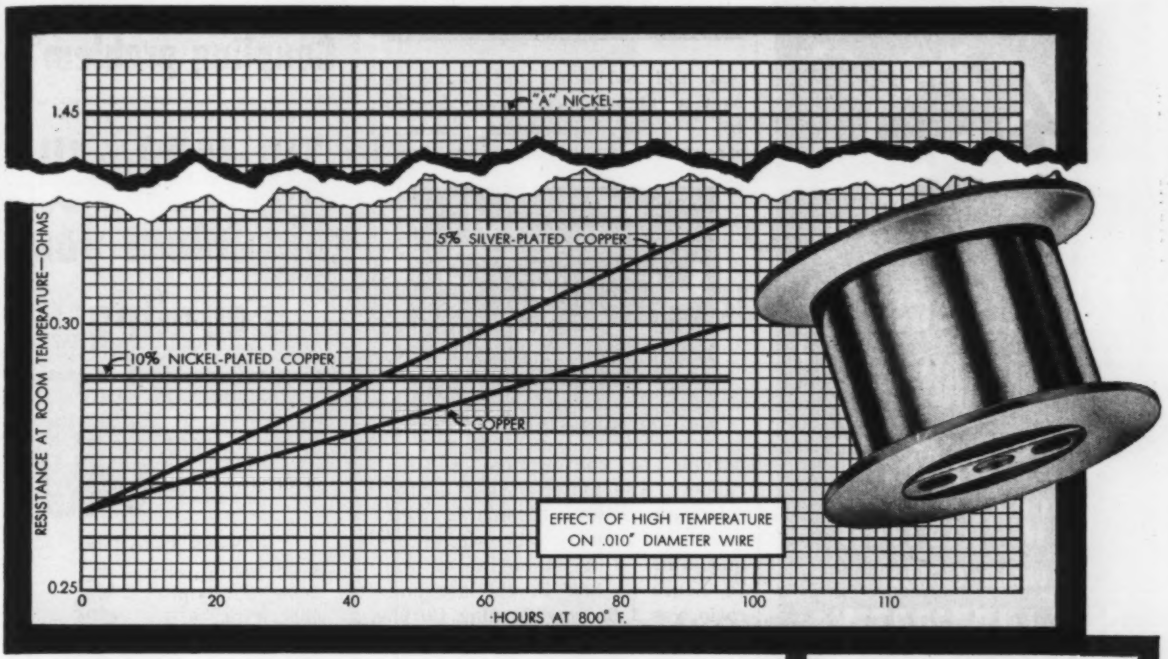


Circle 468 on page 19

## Heat-Resistant Rubber

### withstands swelling by aircraft fuels and oil

Silastic LS-53 fluoro-silicone rubber for use on jet-powered planes combines the properties of silicone rubbers and fluorocarbon plastics. It resists swelling in contact with jet fuels, gasoline, high aromatic



# Nickel-plated copper...

## for high conductivity at elevated temperatures

SYLVANIA's Nickel-plated copper wire combines the conductivity of copper with the corrosion-resistant properties of nickel for applications involving temperatures ranging from 350° Fahrenheit to 700° Fahrenheit.

Equal lengths of Nickel-plated copper and three other wires were heated in air at 800° Fahrenheit for an extended period to determine the effect of heat on conductivity.

Nickel-plated copper, more than any of the other wires except for pure nickel, holds its original low resistance. It's this feature which, in many cases, has made Nickel-plated copper more desirable than costlier wires used where conductivity must remain constant under high temperature environment.

Nickel-plated copper wire can be supplied in a full range of diameters (from .250" to .005".

Sylvania is the only major wire supplier with complete facilities for plating and cladding wire. This makes it possible to provide you with an experienced, objective recommendation as to whether a plated or a clad wire is best suited for your application.

In addition, Sylvania's Parts Division offers you complete 4-way service including custom molded plastic parts, small metal parts ranging from wire forms to deep drawn parts, and special electronic components. Write for the "Portfolio of 4-way Service" and the new technical bulletin on Nickel-Plated Copper Wire.

**SYLVANIA** PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE

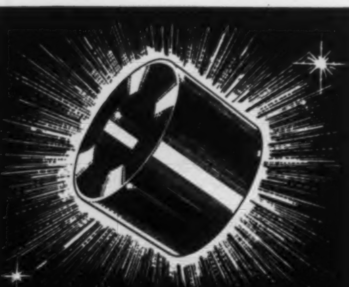
METAL STAMPINGS

MOLDED PLASTIC

ELECTRONIC COMPONENTS

4-way service from one source

Circle 596 on page 19



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LONG WEARING
LOW FRICTION

*UNIQUE (OIL-FREE)*

SELF-LUBRICATING
BUSHINGS

EXCELLENT DURABILITY • CONSTANT COEFFICIENT OF FRICTION • APPLICABLE OVER A WIDE TEMPERATURE RANGE (−450° to +700°F.)
OPERATE DRY, OR AT HIGH SPEEDS SUBMERGED IN WATER, GASOLINE OR LIQUID GASES • NON-CONTAMINATING IN FOODSTUFFS • EXCELLENT FOR CURRENT-CARRYING BEARINGS

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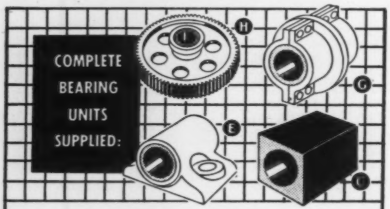

BRUSHES • CONTACTS

GRAPHALLOY has high-performance electrical properties: *low electrical noise, low and constant contact drop, high current density, minimum wear!*

Brush Holders and Assemblies, Coin Silver Slip Rings and Assemblies available.

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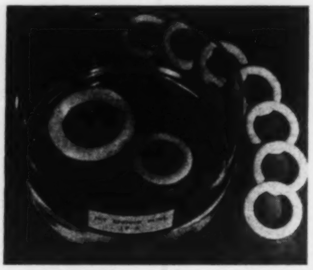
COMPANY
STREET
CITY ZONE STATE

*Circle 597 on page 19*

oils and solvents, and performs over a temperature range of −80 to 400 F. Hardness, tensile strength and elongation are comparable to conventional silicone rubbers. The material is available fully compounded. Compared with a general purpose silicone rubber in contact with jet engine oil for 70 hours at 350 F, the swelling ratio was 1:6. **Dow Corning Corp.,** Midland, Mich.



*Circle 469 on page 19*

### *Multiplier Phototube*

**detects and measures ultraviolet radiation**

Head-on type multiplier phototube is intended for detection and measurement of ultraviolet radiation and applications involving low-level radiation sources. Tube is constructed with fused-silica faceplate which transmits radiant energy in ultraviolet region down to and below 2000 angstroms. At 2000 angstroms, spectral sensitivity is over 50 per cent of maximum response. Spectral response covers range from 2000 to 6500 angstroms, with maximum response occurring at approximately 4400 angstroms. Features include semitransparent cathode having minimum diameter of 1⅝ in., ten electrostatically focused multiplying (dynode) stages, focusing electrode with external connection, and capability of multiplying feeble photoelectric current pro-

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THOMAS will help select your coupling

DOUBLE FLEXING
DBZ—for high speed, heavy duty drives

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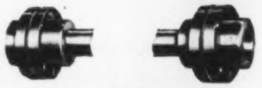
SS—for engine-driven generator sets with outboard bearings

DOUBLE FLEXING
AMR—for engine and medium speed drives



FLOATING SHAFT
BMR—for heavy duty service with excessive misalignment

Your Thomas Sales Engineer, backed by 40 years of coupling experience, will help you select the correct type Flexible Coupling from the Thomas catalog. Or, he will engineer special variations for unusual cases. For all practical purposes, properly installed and operated within rated conditions, Thomas Flexible Couplings will last *forever.*

NO LUBRICATION • NO MAINTENANCE
THERE ARE NO WEARING PARTS

Under load and misalignment, only Thomas Flexible Couplings offer *all* these advantages:

1. Freedom from backlash—torsional rigidity
2. Free end float
3. Smooth, continuous drive with constant rotational velocity
4. Visual inspection while operating
5. Original balance for life

*Write for Engineering Catalog 51A and the name of the Thomas Flexible Coupling engineer nearest you.*

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

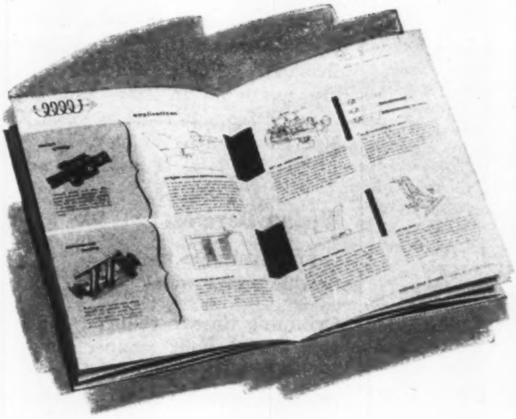
*Circle 598 on page 19*

Saginaw
Screws
Splines
Saginaw STEERING GEAR DIVISION
GENERAL MOTORS CORPORATION

# FREE! YOUR NEW ACTUATOR and SPLINE "PROBLEM SOLVER"!

## New 1957 Engineering Data Book from World's Largest Producers of Ball/Bearing Screws and Splines

36 pages crammed with time-, work-, and money-saving facts: Principles • Types • Basic Operations • Coupling Methods • Efficiency • Versatility • Advantages • Selection Factors • Design Data • Sample Problems, etc.



**SAGINAW b/b SCREWS** are *90%-98% efficient* (compared to 15%-20% efficiency of Acme screws). Require ⅔ LESS torque and power for same linear output—with consequent weight, space reductions. Function normally at −75° to +250° F. Two types: precision-ground or commercial rolled-thread. Have been built 1½ in. to 39½ ft. long.

**SAGINAW b/b SPLINES** have *40 times lower coefficient of friction* than sliding splines; transmit or restrain high torque loads far better; permit vital power, weight, space reductions. Have been designed 3 in. to 10 ft. long.

**Saginaw**
**ball bearing**
**Screws & Splines**

SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

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Please direct inquiries to advertiser, mentioning MACHINE DESIGN

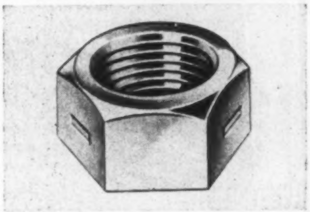
duced at cathode by median value of 400,000 times. **Radio Corp. of America,** Tube Div., Harrison, N. J.

*Circle 470 on page 19*

## Lock Nut

**double-chamfered unit has center locking**

Lock nut can be applied from either end, is double chamfered, and has locking feature in center. Nut does not depend on friction against work or tightening torque for locking action and can be used on commercial or heat-treated bolts without damage to bolt threads and with maximum re-application torque. Controlled upward and downward displacement of central threads provides locking ability. Nuts are available in aluminum, brass and steel in sizes from ¼ thru ½-in., both fine and coarse threads. Single chamfered nuts are available in fine and coarse threads from 9/16 thru ⅞-in. **Grip Nut Co.,** South Whitley, Ind.

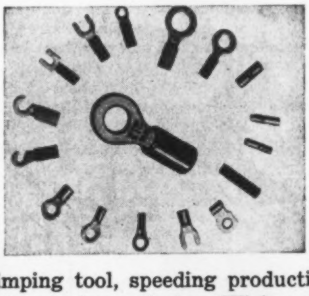


*Circle 471 on page 19*

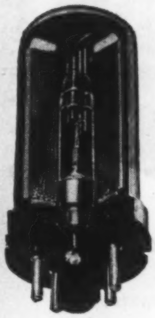
## Wiring Devices

**are available in wide range of styles**

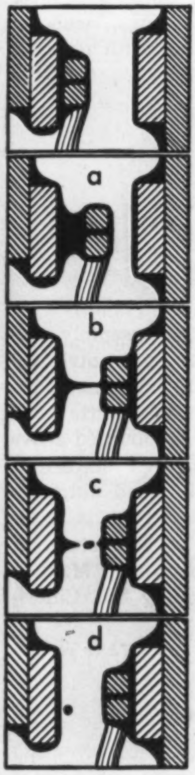
Crimping time is reduced and positive, permanent connections can be made with wiring devices which provide ¼-in. long target area for crimping tool, speeding production and reducing rejects. Wiring devices are one-piece soft copper, tin-electroplated for high conductivity



# BILLIONS



## OF OPERATIONS WITH **NO CONTACT WEAR OR BOUNCE**

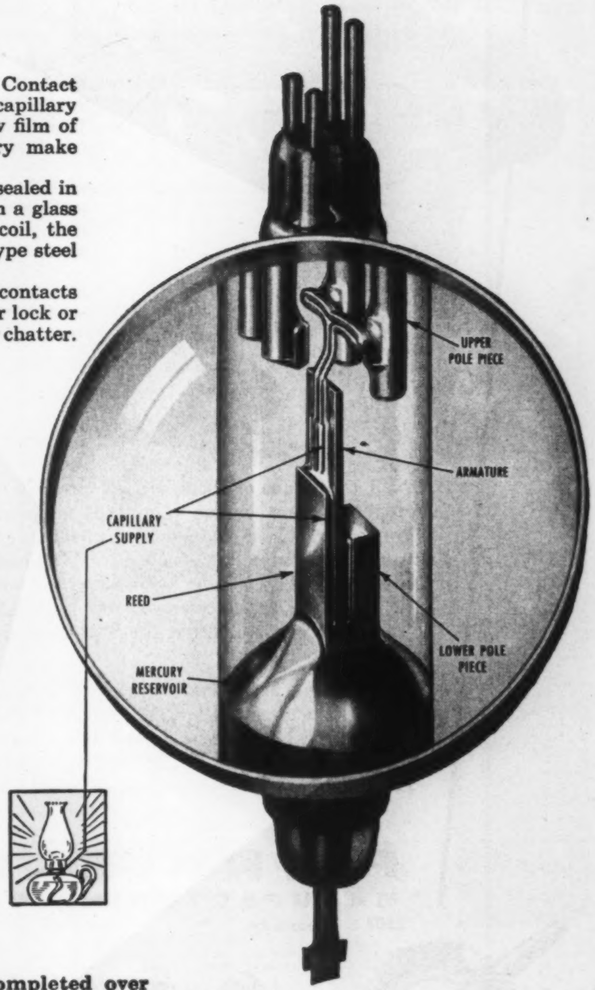


Contacts of CLARE Mercury-Wetted Contact Relays are constantly renewed. By capillary action, like that of a lamp wick, a new film of mercury coats each contact with every make and break.

The magnetic switch is hermetically sealed in a high-pressure hydrogen atmosphere in a glass capsule. Surrounded by the operating coil, the capsule is enclosed in a vacuum-tube-type steel envelope.

Unlike ordinary relay contacts, these contacts never wear down; never get dirty; never lock or weld; never get out of adjustment; never chatter.

Drawings (left) from stroboscopic photographs, show the cycle: (a) Filament of mercury forms between the contacts as they separate. (b) This becomes narrower in cross section and (c) finally parts at two points, allowing a globule of mercury to fall out. (d) The momentary bridging of the parting contacts—and the extremely fast break which ends it—minimizes the arc and adds greatly to contact load capacity. Contact closure between the two liquid surfaces bridges any mechanical chatter and prevents any chatter from appearing in the electrical circuit.



**Relays on continuous test have completed over 3,000,000,000 operations with a contact load of 5 amperes at 50 volts—and are still going strong.**

**Send for Clare Engineering Bulletins Nos. 120 and 122. Address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare & Co., 659 Bayview Ave., Toronto 17. Cable Address: CLARELAY.**

# CLARE RELAYS

**FIRST in the industrial field**

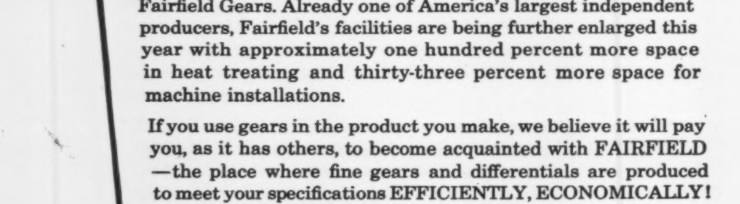
*Circle 600 on page 19*

For GEARS to build AMERICA'S ROADS

GEARS, thousands of them, will go into the construction machinery needed for our nationwide program of building highways and roads. An increasing number of these will be Fairfield Gears. Already one of America's largest independent producers, Fairfield's facilities are being further enlarged this year with approximately one hundred percent more space in heat treating and thirty-three percent more space for machine installations.

If you use gears in the product you make, we believe it will pay you, as it has others, to become acquainted with FAIRFIELD—the place where fine gears and differentials are produced to meet your specifications EFFICIENTLY, ECONOMICALLY! *Your inquiry will receive prompt attention.*

FAIRFIELD
MANUFACTURING CO.
2307 S. Concord Rd. Lafayette, Indiana



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*Circle 601 on page 19*

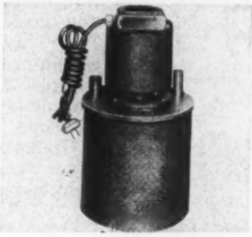
and maximum corrosion resistance. Devices are available in ring, spade, hook tongue, snap-plugs, flag-type, parallel, butt, 3-way Y, and 4-way X to fit wire sizes 22-16, 16-14 and 12-10. **Electric Terminals Corp.**, 2021 Center St., Cleveland 13, Ohio.

*Circle 472 on page 19*

## Pump and Tank Assembly

### high-capacity unit handles abrasive materials

No. 4072-T pump and tank unit handles abrasive materials such as silicon carbide solutions on honing, lapping and ultrasonic machines. There are no bearings, seals or packings in contact with material being pumped. The assembly consists of a 1/10-hp centrifugal pump, tank with inlet and discharge connections, electric cord and plug. Motor is mounted above the tank lid. An even mixture of the liquid is maintained automatically in the tank. Tank is available in stainless steel or standard carbon steel. **Ruthman Machinery Co.**, 1811 Reading Rd., Cincinnati 2, O.



*Circle 473 on page 19*

## Wire-Thread Insert

### stainless-steel unit for integral thread casting

Stainless-steel insert, developed specifically for sand-casting operations, has application where durable, corrosion-resistant threads are required in cast-metal parts. It permits high-speed casting of integral threads. The insert is tightly wound to prevent flow of hot metal into female threads and to maintain correct thread pitch in the casting. Insert is placed directly in the mold on sand cores, and molten metal flows around it,

# LONGER SOLENOID LIFE...

with NAMCO'S exclusive "HARDMETAL"-welded plunger bonding

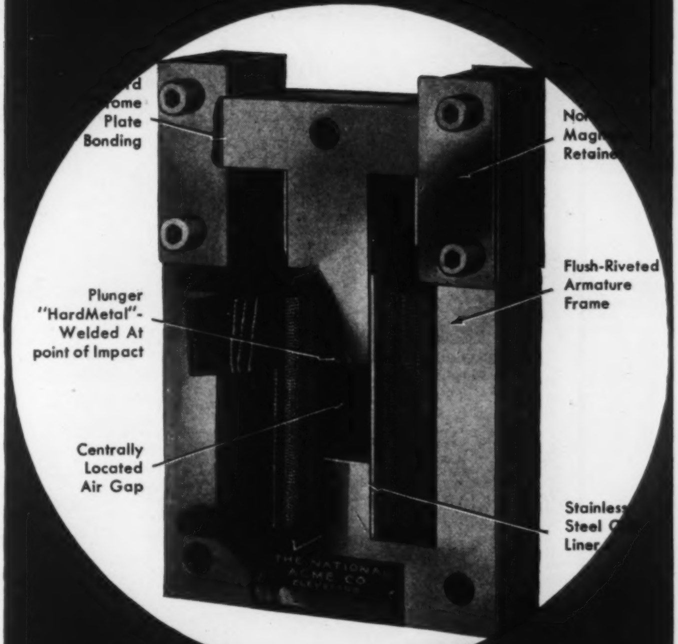

rd
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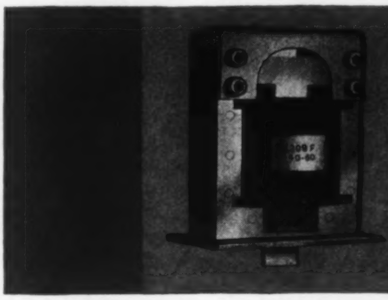
Plate
Bonding
No
Magn
Retaine
Flush-Riveted
Armature
Frame
Plunger
"HardMetal"-
Welded At
point of Impact
Centrally
Located
Air Gap
Stainless
Steel
Liner
THE NATIONAL
ACME CO

## Standard or Custom Models To Fit Your Design

"HardMetal"-welded plunger bonding prevents mushrooming at the vital point of impact—withstands incessant pounding of the plunger on the frame. Long plunger life, and thus long solenoid life, is further insured by hard chrome plating upper guide edges of plunger laminations to reduce friction and wear.

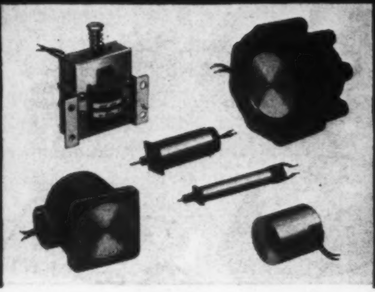
Namco standard solenoids are available in six series of pull and push types; custom-engineered solenoids in every size and type can be made to meet your specifications.

**Standard "HardMetal"-Welded Solenoids are furnished push or pull type in sizes with ratings from 2-1/2 to 21 pounds at 1/2" stroke and from 2 to 25 pounds at 1" stroke.**



← Saddle stop applied to Series K200 standard Namco push type solenoid.

To meet specific job requirements, solenoids of special shapes and sizes are designed and built through cooperation of our engineers with yours. →

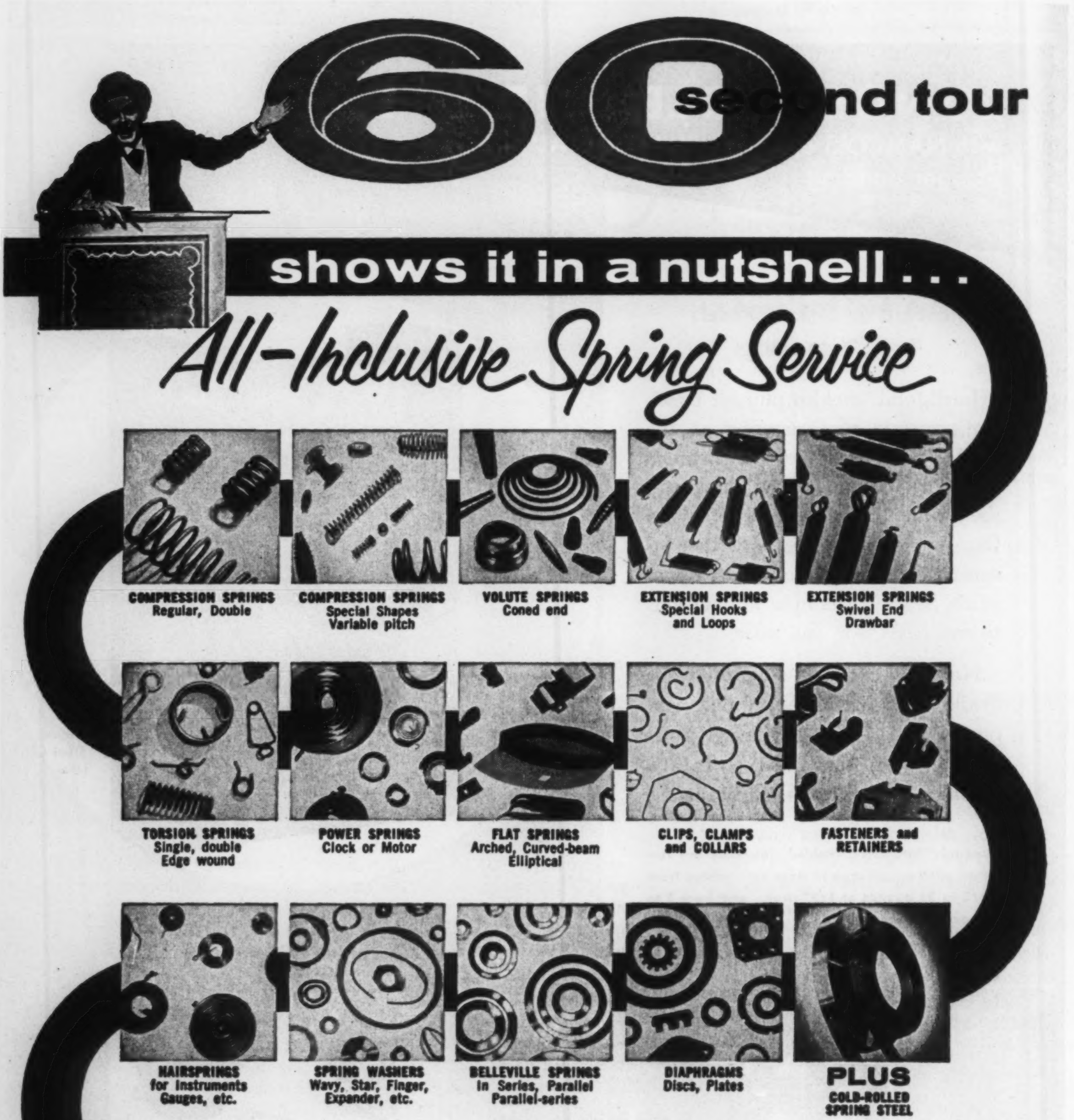


**Ask us to send a National Acme Representative to discuss your problems, or if you want more information first—send for BULLETIN EM-52.**

ELECTRICAL MANUFACTURING DIVISION

# National Acme

**THE NATIONAL ACME COMPANY • 188 EAST 131ST STREET • CLEVELAND 8, OHIO**



# 60 second tour

## shows it in a nutshell . . .

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**PLUS**
**COLD-ROLLED
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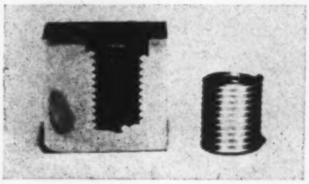
*Divisions of*

# ASSOCIATED SPRING CORPORATION

*Circle 603 on page 19*

forming a fusion bond. After casting, sand is removed by blast cleaning, leaving the stainless steel threads. Since coils are flexible, stresses are not concentrated around the insert and cracking of the cast is avoided. **Heli-Coil Corp.,** Shelter Rock Rd., Danbury, Conn.

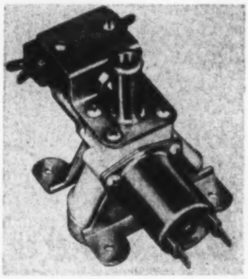


*Circle 474 on page 19*

## *Mixing Valve*

**adjusts water temperature by opening valves alternately**

Three-temperature thermostatic water mixing valve supplies water of desired temperature. Valve utilizes externally mounted switch that alternately opens and closes hot and cold water solenoid valves so rapidly that flow of water supplied is of uniform temperature. Unit is powered by a thermostatic element which supplies power to the switch controlling the solenoid valves as required to produce desired temperatures, either hot, cold, or a mixture. **Detroit Controls Corp., 5900 Trumbull Ave., Detroit 8, Mich.**



*Circle 475 on page 19*

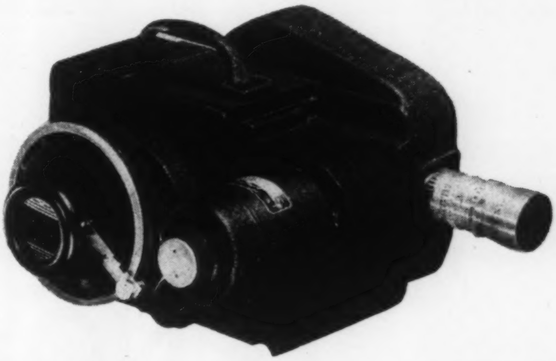
## *Electromagnetic Clutch*

**provides gradual engagement**

Electromagnetic multiple disk clutch is designed for step by step acceleration of large masses in main drives, or as an auxiliary or feed drive for precise control

(*Continued on Page* 180)

**This is a continuous coal miner in operation.** Its maker, Joy Manufacturing Company, wanted to know how the cutter bits performed when cutting coal and pyrites. But the bits moved too fast to see.



**This is a Kodak High Speed Camera.** Joy engineers took it down in the company's coal mine laboratory and used it to take 16mm movies of the cutter bits in action at speeds up to 3200 frames a second.

When they projected the movies at a normal 16 frames per second, the action was slowed as much as 200 times on the screen. Then they could see the action of the cutter bits at different angles and positions in the holding chain, determine the best possible arrangement for maximum cutting efficiency.

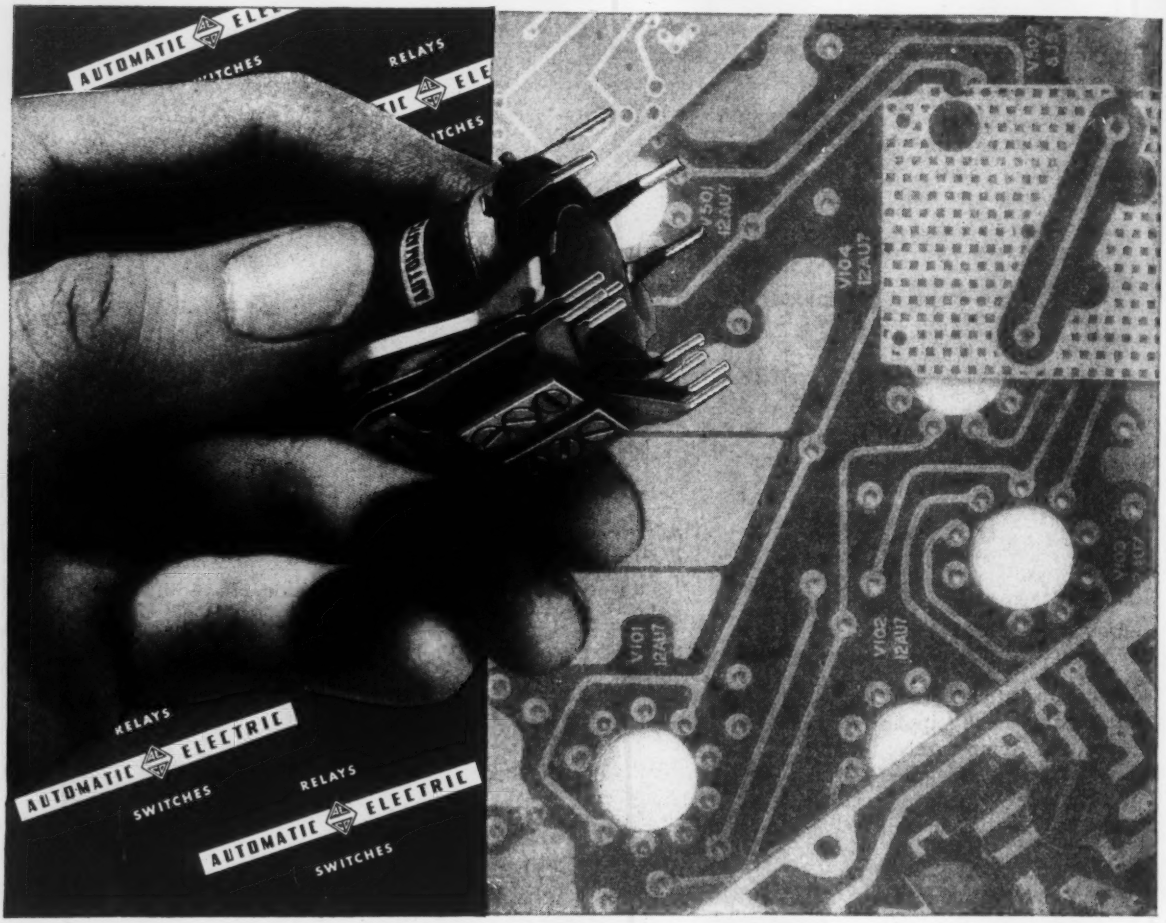
The Kodak High Speed Camera is a practical instrument for practical engineers who would rather see what's happening than waste time guessing. The booklet "High Speed Motion Pictures at the Service of the Engineer" will give you both information and ideas. For your copy write:

**EASTMAN KODAK COMPANY, Rochester 4, N.Y.**

**the Kodak**
***HIGH SPEED* Camera**

Kodak

*Circle 604 on page 19*



# NOW!

## dependable relays for printed circuits

Maybe you, too, have been awaiting availability of a *good* relay for direct insertion into printed circuits. Now Automatic Electric can solve your problem with a miniature relay that is just right.

120 million operations, without a single readjustment or relubrication! That's what you get from this rugged, improved Series SQPC Relay, because it features a special *heavy-duty* bearing and bearing pin. Also a recess in the bearing plate retains an adequate supply of lubricant for long-term lubrication of the bearing pin.

Consider these additional advantages:

1. The sections of the terminals that insert into the printed circuit board are NOT brazed or welded into place, but are integral parts of the coil terminals and contact springs—thus preventing internal loss in conductivity or continuity.
2. Terminal design permits direct plug-in of the relay into a printed circuit board, ready to be secured in place with any acceptable soldering technique.

Usually the desired contact spring combination, or pile-up, is sufficiently large so that additional mounting (support) of the relay is not necessary.

*SQPC Miniature Printed Circuit Relays* are available with many different contact spring arrangements, and for a multitude of applications. Springs can be made of phosphor-bronze, "Bronco" metal, or other special-purpose materials, as required.

Of course the long life, heavy-duty features of the improved SQPC Relay can be had in the conventional type of plug-in relay, if regular sockets are preferred for use, whether in printed circuitry or other applications.

*To get complete details, write:* Automatic Electric Sales Corporation, 1033 West Van Buren St., Chicago 7, Illinois. *In Canada:* Automatic Electric (Canada) Ltd., Toronto. *Offices in principal cities.*

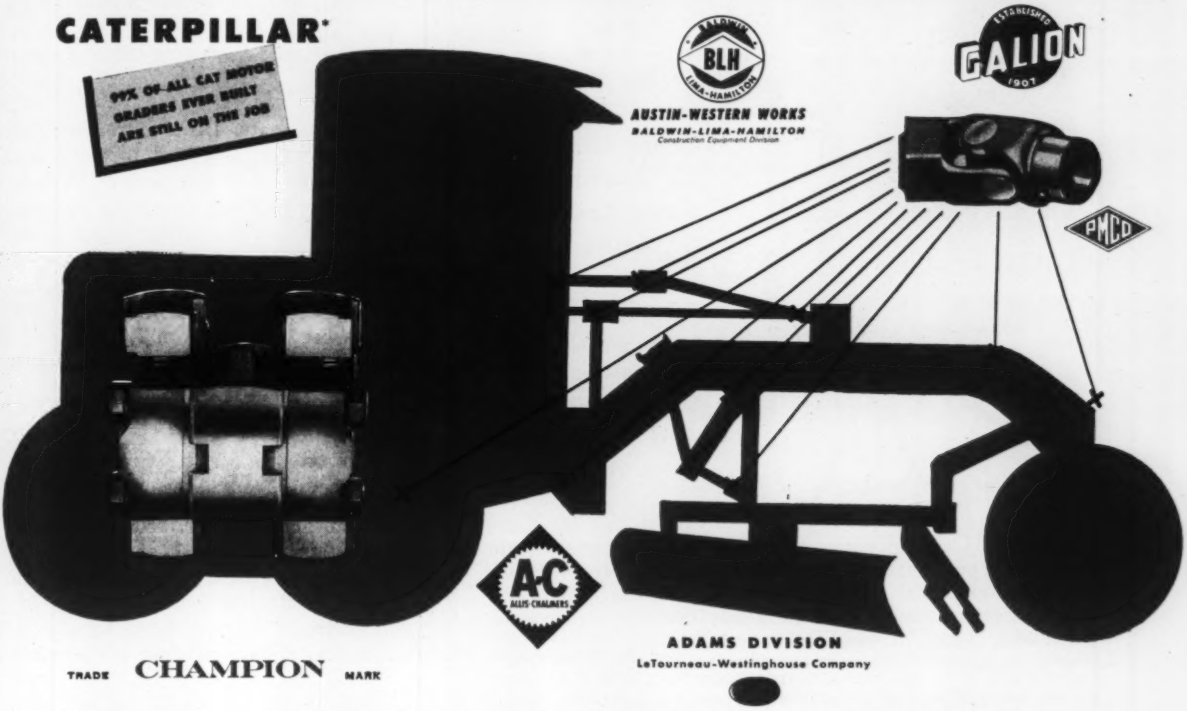
**AUTOMATIC ELECTRIC**

*Originators of the dial telephone • Pioneers in automatic control*

GENERAL SYSTEM

Circle 605 on page 19

# RELIABLE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Whether for close-coupled main drive lines or for exposed steering and adjustment drives, designers with JOINT problems have learned to rely on MECHANICS. Where joints must run all day at high angles — where there are severe shock loads— where wide angles and long slip are common — and where dirt and/or moisture constantly are present — MECHANICS Roller Bearing UNIVERSAL JOINTS are the accepted solution. *Lubrication is so tightly sealed in that dirt and moisture cannot enter.* If you have a "tough" joint problem, make use of MECHANICS field engineers' wide experience.

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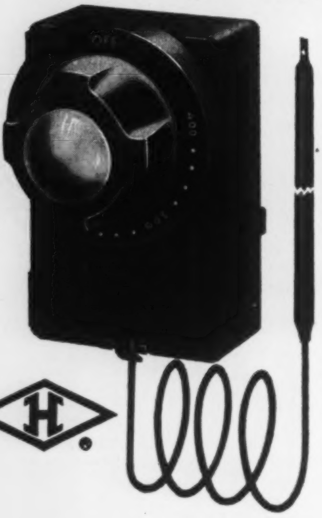


# Complete NEW Line of "Diamond H" Thermostats (Series 270)

**For**

- Grease Kettles
- Steam Tables
- Coffee Urns
- Air Conditioning
- Motor Control
- Oil Baths
- Platens
- Range Ovens
- Laboratory Equipment
- Solenoid Control
- And Many Other Applications

"Diamond H" engineering, noted for building better, more dependable performance into smaller space in relays, switches and other electrical and electronic controls, has now developed an entire new line of extremely compact thermostats for a wide variety of applications.

Series 270 thermostats provide accurate calibration, consistent low-differential operation and positive, over-the-center, quick action (to make or to break on rising temperature) in single pole, single throw and double pole, single throw models.

Circuits vary from simple on-off to special selector sequencing to meet special requirements, including single dial, automatic preheat operation for oven models. Temperature ranges are available to suit the application.

Some units may be equipped with terminals for remote pilot light connection; others with terminal clips for direct connection of pilots. Spade terminals simplify wiring.

UL approved standard ratings up to 25 A., 125-250 V., A. C., are available. Horsepower ratings up to 1 h. p., 120-240 V., A. C., special bulb and capillary lengths and sizes, together with special spindle and mounting arrangements, and dials in a choice of colors and marked to suit the customer, may also be obtained.

Descriptive bulletins T270 and T276H are yours on request. "Diamond H" engineers are prepared to work out your specific requirements with you. Tell us your needs.

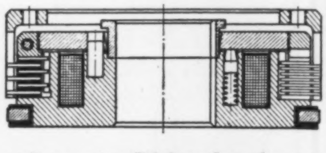
**THE HART MANUFACTURING CO.**
**118 Bartholomew Ave., Hartford, Conn.**

*Circle 607 on page 19*

## New Parts

*(Continued from Page 177)*

and quick response in machine tools and similar applications. Unit has small dimensions in relation to magnitude of torque. Magnetic flux does not pass disk bundle, so bundle can be designed and formed without regard to magnetic circuit requirements. Disks of various materials can be paired to work dry or in oil, with surfaces of various types according to torque requirements. Torque rating range is 10 to 15,000 lb-ft. Voltage is 24 v dc. **McCauley Industrial Corp.,** Power Transmission Div., 219 Parker Ave., Dayton 7, Ohio.



*Circle 476 on page 19*

## Corrosion Preventive

### wax-base coating protects metals from severe exposure

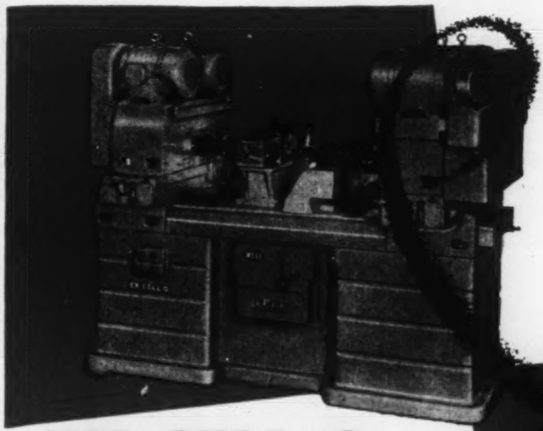
Nonflammable corrosion preventive coating for metal surfaces is a water emulsion of waxes and oils in combination with corrosion inhibitors. When applied by dip or spray, material forms a uniformly firm, transparent, wax-type coating. After a brief drying and curing period, coating cannot revert to emulsion, and will not wash off. Coated parts remain protected under conditions of rain, sleet, hail and high humidity for over two months. Material resists fingerprint corrosion, whether metal parts are handled before or after application of coating. **Dearborn Chemical Co.,** Merchandise Mart Plaza, Chicago 54, Ill.

*Circle 477 on page 19*

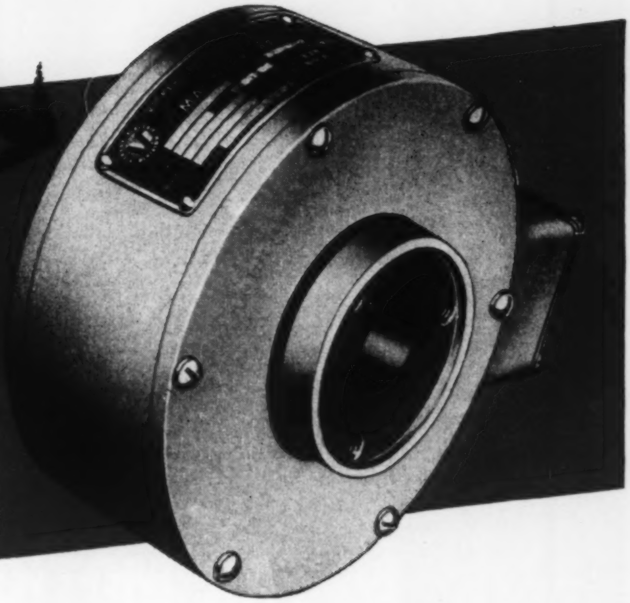
## Shaded-Pole Motor

### reversible unit has low vibration resonances

Reversible shaded-pole motor designed for light commercial fans is available in ratings from 1/30 to 1/12-hp and offers reversibility comparable to that of capacitor motors of similar size and rating. Motor is designed to minimize vibration resonances and provides



# FOR SMOOTHER QUIETER and MORE DEPENDABLE PRECISION BORING MACHINE OPERATION



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**uses the**

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Ex-Cell-O Corporation of Detroit, well-known manufacturer of quality machine tools, equips its precision boring machines with Vickers MAGNEBRAKE, because this unique braking equipment provides the important advantages of . . .

- **LONGER, TROUBLE FREE LIFE,** requiring much less brake maintenance than ordinary friction-type braking systems . . . thereby minimizing and in some instances, eliminating machine down-time. There are no shoes or linings in Vickers MAGNEBRAKES — nothing to wear out — your assurance of far longer, trouble free service life.
- **SMOOTHER, FASTER, QUIETER PERFORMANCE,** without troublesome grab or chatter. Since torque is independent of speed in the MAGNEBRAKE, stops are far smoother . . . thereby preventing transmission of brake vibrations through the spindle and to the work.

Vickers MAGNEBRAKES can serve you with the efficiency, dependability and durability needed for today's faster working duty cycles, higher operating speeds and higher inertia loads. Vickers engineers are thoroughly experienced in the application of industrial clutches and brakes. They will be happy to examine your problem and to offer competent engineering advice, without obligation. Write today for more detailed information.

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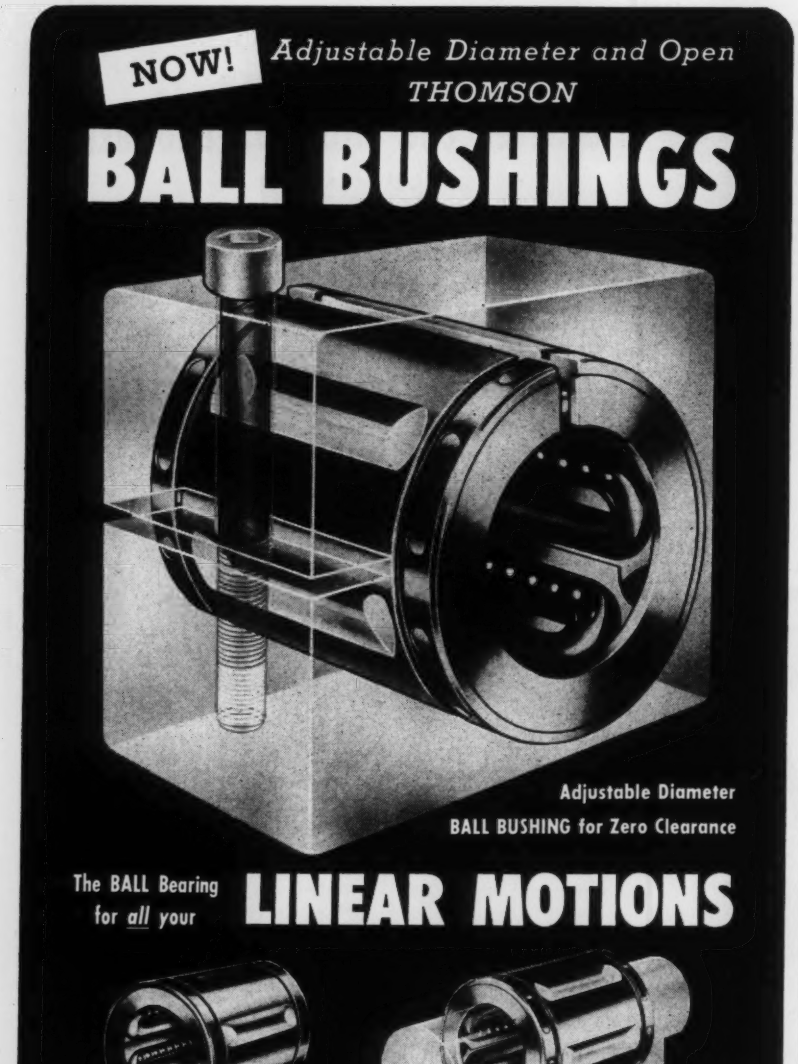
*Circle 608 on page 19*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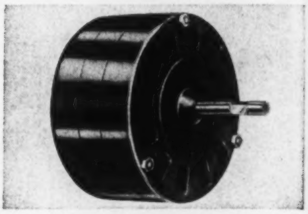
essentially flat noise characteristics from 25 to 1500 cps. Features include laminations designed for low leakage flux, high copper-to-iron ratio and die-cast rotor structure for maximum uniformity of rotor resistance. **Fasco Industries Inc.,** 255 N. Union St., Rochester 2, N. Y.

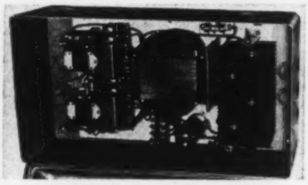


*Circle 478 on page 19*

## Braking Controller

**for ac motors**
**is packaged unit**

Packaged control and braking system fits any standard ac motor. Electrical braking torque diminishes as motor decelerates until smooth, definite stop results, normally in same time required for acceleration of driven equipment. There is no possibility of reversing. Braking controller is available with braking unit only, or as complete braking and starting unit for either nonreversing or reversing service. Circuit breaker, disconnect, and other modifications are available. **Westinghouse Electric Corp.,** P. O. Box 2099, Pittsburgh 30, Pa.



*Circle 479 on page 19*

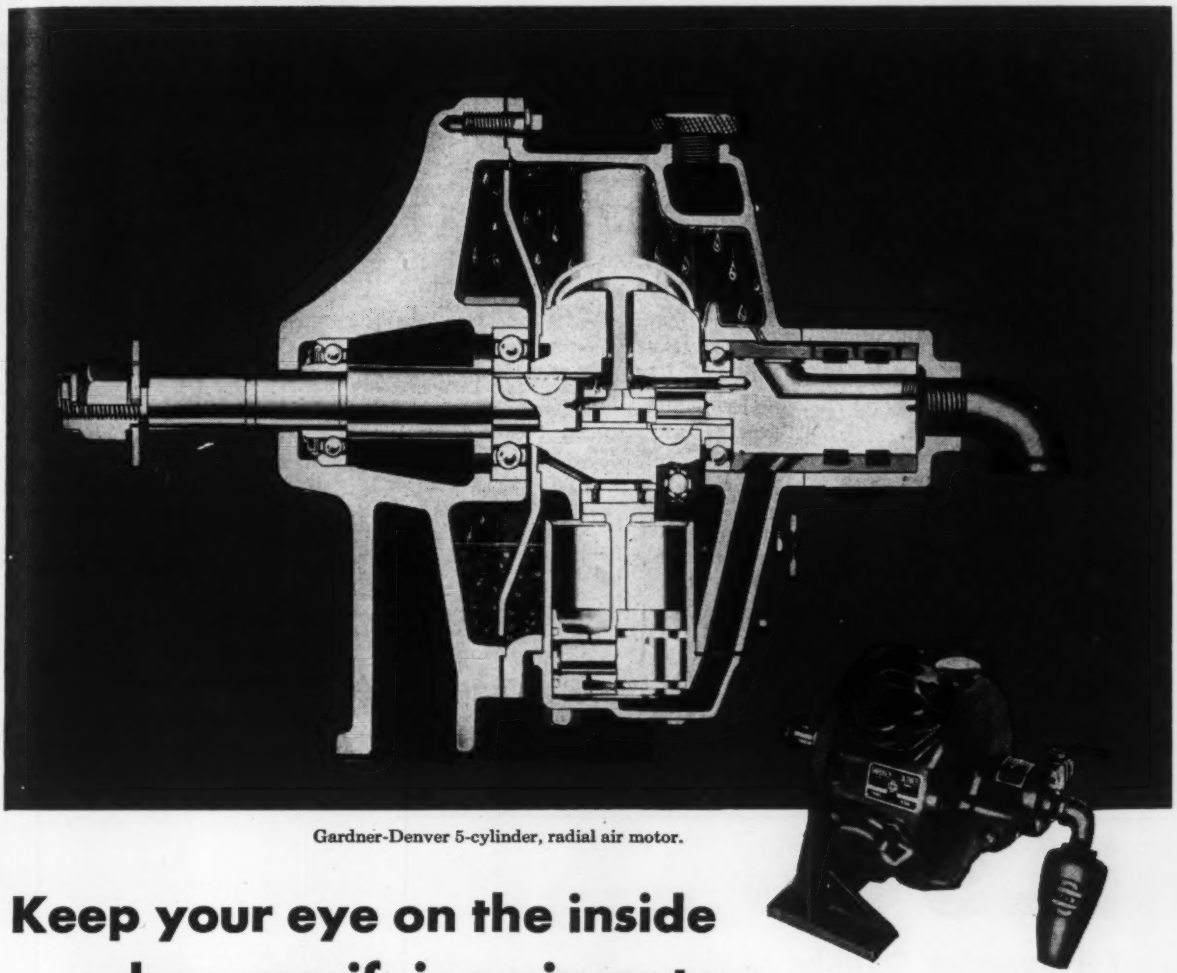
## Solenoid

**lightweight unit**
**has $^3/_8$-in. stroke**

Solenoid, meeting requirements for a small, light, economical actuator, is designed for both continuous and intermittent duty in industrial and commercial use. Suitable for ac and dc applications in automatic machines requiring a moderate amount of power, such as record-

*Circle 609 on page 19*

**Gardner-Denver . . .** Serving the World's Basic Industries



Gardner-Denver 5-cylinder, radial air motor.

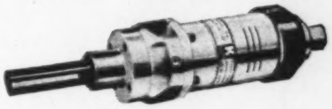
# Keep your eye on the inside ...when specifying air motors

Here's one product you can specify and forget when it comes to compressed air powering. Precision workmanship applied to top-quality materials is the reason. Gardner-Denver multi-use air motors excel in safety, control flexibility, high torque and freedom from overload damage.

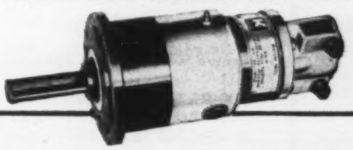
5 sizes; 3 to 16 h.p. . . . direct drive or built-in gear reduction . . . reversible or non-reversible—a choice of power and speed for many applications.

JUST A FEW JOBS WHERE GARDNER-DENVER AIR MOTORS PUT IN A FULL DAY'S WORK: Bit Grinders • Bending Rolls • Grout Mixers • Concrete Mixers • Blowers • Pumps • Hoists • Conveyors • Saw Mill Machinery • Engine Starting.

Keller Tool 1 h.p. Rotary Vane Air Motor.



Keller Tool 70A Axial Piston Air Motor.



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FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

Gardner-Denver Company, Quincy, Illinois
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*Circle 610 on page 19*

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**Durakool** ALL-STEEL MERCURY *Switches*

*Circle 611 on page 19*

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*For Superior Quality*
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- ☐ Pure copper, 100% conductivity
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- ☐ U/L-CSA Approved
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- ☐ Advanced designing
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- ☐ Speedy installation
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- ☐ No special tools needed
- ☐ All screws wax-treated for better clamping

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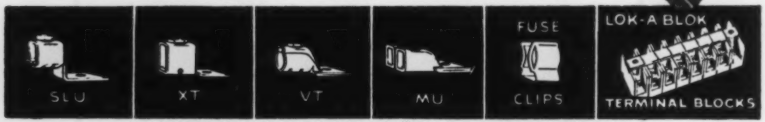
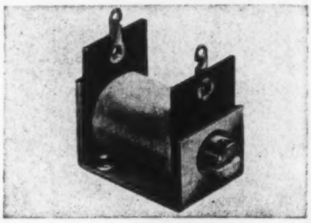


*Write for Catalog #50 and Samples*
**ILSCO CORPORATION**
5752 MARIEMONT AVE. CINCINNATI 27, OHIO

ing and vending equipment, solenoid has a stroke of $\frac{3}{8}$-in. max. Available in three mounting styles, unit operates on 115 v. Coil of solenoid is varnish impregnated for protection under conditions of high humidity. All ferrous parts are cadmium plated to prevent corrosion. **Artisan Electronics Corp.**, Morristown, N. J.



*Circle 480 on page 19*

## Lever Switch

**miniature switch has removable lever**

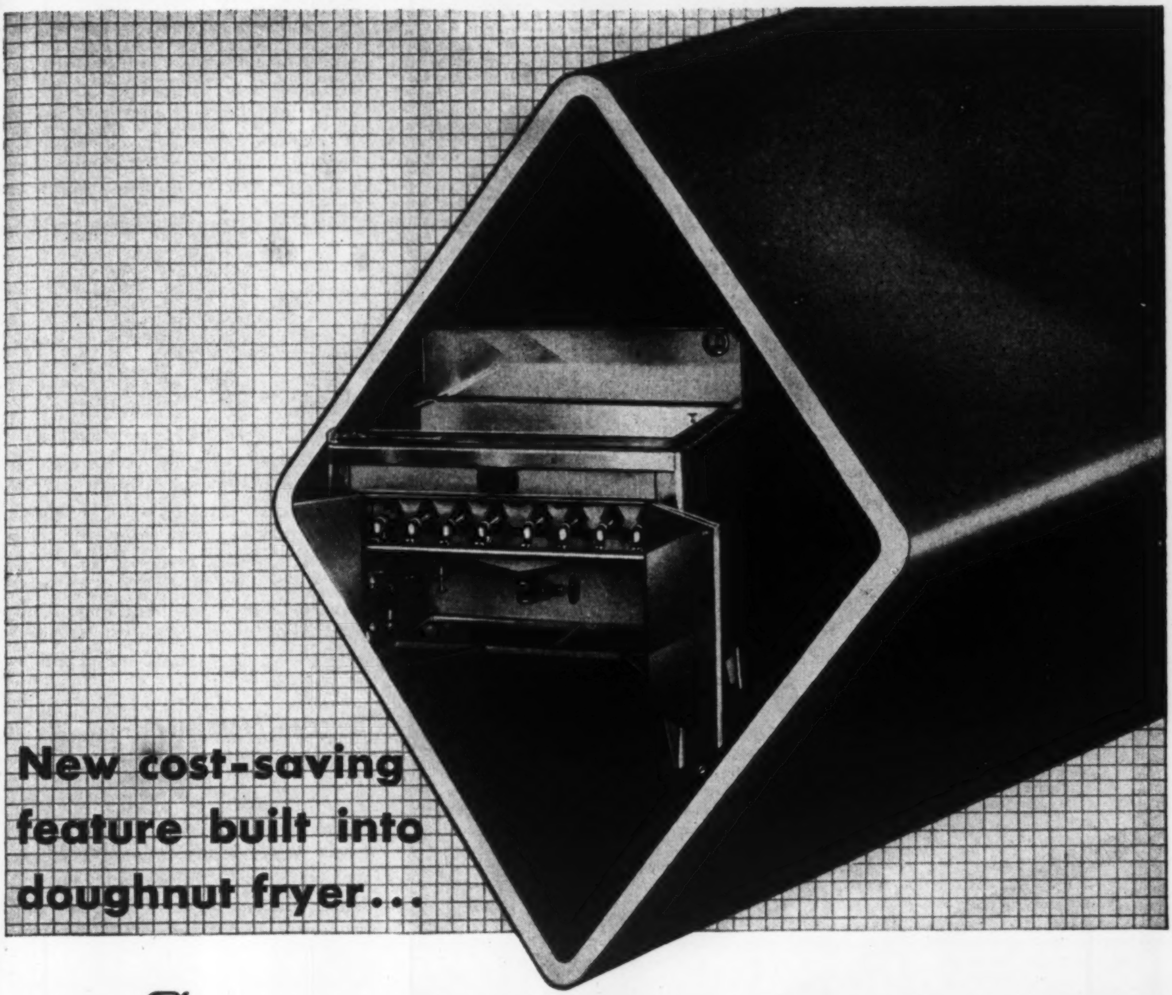
Hinged lever switch is designed for ease of removal or assembly of lever, allowing use of standard levers with added secondary operations to meet special application requirements. Operating force is 10 to 18 *g* and movement differential is 0.020 to 0.080-in. Fully enclosed switch is of simple design and extremely compact. Blade design provides maintained contact and elimination of bounce. Electrical rating is 15 amp, 125 and 250 v ac. **Detroit Controls Corp.**, TyniSwitch Dept., 800 Union Ave., Bridgeport, Conn.

*Circle 481 on page 19*

## Vibration Isolator

**may be mounted in any position**

Diagonal-spring vibration isolator and shock mounting features all-metal construction for maximum service life and wide operational temperature range. Unit has non-



# New cost-saving feature built into doughnut fryer...

# with Carpenter Diamond-Shaped Stainless Tubing

• A new feature in this volume doughnut fryer is the use of super sanitary heating tubes made from diamond-shaped Carpenter Stainless Tubing. The diamond shape permits faster, more economical heating because of the greater heating surface in contact with the fat. Doughnut crumbs cannot settle on the tubes, making cleaning easier and preserving the fat longer.

This is just one more example of combining the inherent advantages of stainless—high strength-weight ratio, fine appearance, corrosion and abrasion resistance and super sanitation—with the extra benefits of special shapes of Carpenter Stainless Tubing. Why not investigate the possibilities of designing and building the advantages of Carpenter Stainless Tubing shapes into your products. Call your nearest Carpenter Distributor or Branch Office for consultation and information.

MEMBER

**The Carpenter Steel Company,**
**Alloy Tube Division, Union, N. J.**

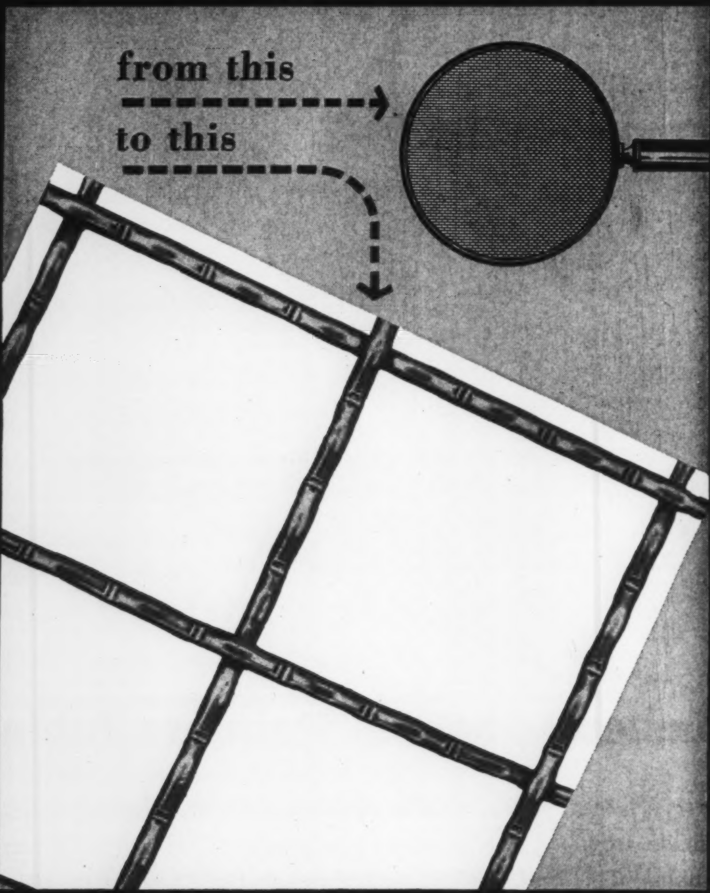
*Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"*

**Carpenter**

more than corrosion resistance

**Stainless Tubing & Pipe**

Circle 613 on page 19



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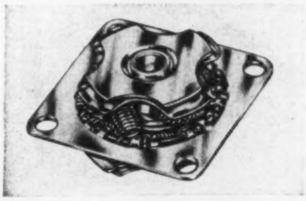
*Circle 614 on page 19*

linear spring characteristics, high damping and all-positional or all-attitude performance. Isolator withstands hours of resonance with input of 0.036-in. double amplitude with equipment mounted either horizontally or vertically. Low amplification at resonance is approximately twice input. Unit withstands repeated 15 *g* shock without loss of efficiency and 30 *g* ultimate. Unit is available in ¼, ½, 1, 2, and 3 lb load ratings. **United-Carr Fastener Corp.,** Uconite Div., Newtonville 60, Mass.

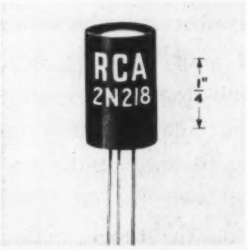


*Circle 482 on page 19*

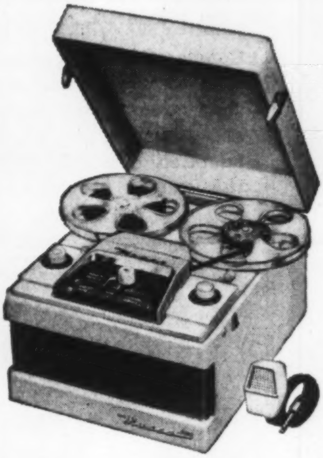
## Junction Transistors

**have flexible leads**

Three germanium p-n-p alloy type junction transistors have flexible leads which may be soldered or welded into associated circuit. Units are hermetically sealed and employ a metal case with external insulating coating. Type 2N218 is designed for 455 kc, intermediate-frequency amplifier applications and is capable of providing power gain of 30 db at 455 kc in common-emitter circuits of quantity-produced receivers. Type 2N219 has controlled characteristics for converter and mixer-oscillator applications in standard broadcast band and has conversion power of 30 db at center of band when used in common-emitter circuits. Type 2N220 is low-noise unit for use in preamplifier or input stages of transistorized audio

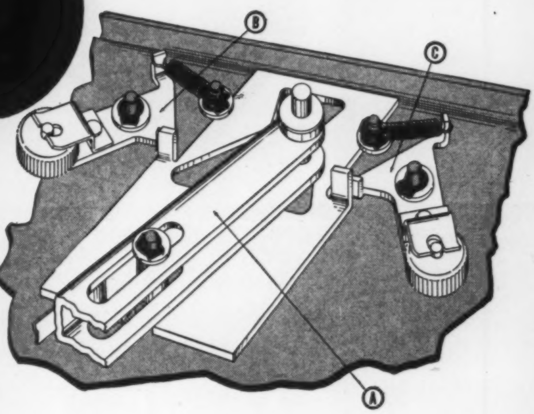


# Waldes Truarc grip rings used on die-cast studs eliminate threading, tapping, other costly machining



**Mark Simpson Manufacturing Co.,** Long Island City, N. Y., uses Waldes Truarc series 5555 Grip Rings to secure parts to studs of the zinc die-cast base of its "Masco 500" portable tape recorder.

The rings—which need no grooves—replace nuts, screws, cotter pins and other types of fastening devices which require threading, tapping, drilling and other expensive machining operations. Because a single cracked or broken stud would render the entire cast base useless—and with it, all assembly completed to that point—the rings also eliminate extremely costly rejects.



**Pivot Assembly** of shift lever (A) is secured by a single Waldes Truarc Grip Ring and washer. Because the washer must be installed over the shift level in a sliding fit, critical tolerances would have to be maintained if a screw or cotter pin were used. The Truarc Grip Ring eliminates that problem: it requires no groove and may be seated over the washer at any point on the stud, automatically compensating for accumulated tolerances in the parts. BRAKE ASSEMBLIES (B and C) use Grip Rings to secure the brake wheel and spring subassemblies. Here again problems of critical tolerances are avoided and expensive rejects eliminated.

**Whatever you make,** there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

**36 functionally different types...** as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

**More than 30** engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

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MD 128

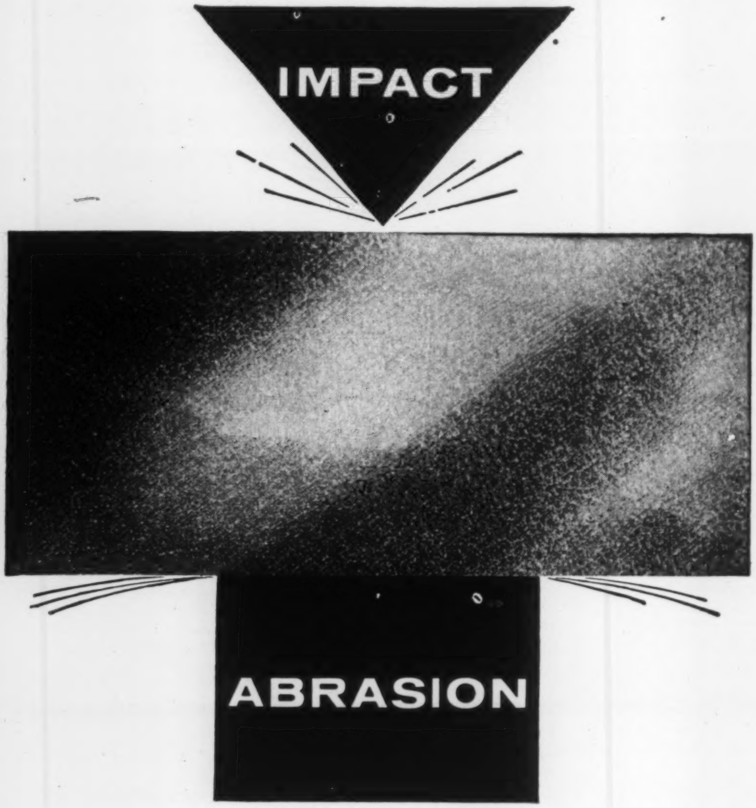
WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

*Circle 615 on page 19*

# AMSCO®

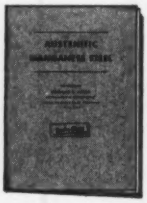
## MANGANESE STEEL

**the toughest steel known for...**



Amsco Manganese Steel actually *absorbs impact energy*. Impact work-hardens the steel's surface to as high as 550 BHN, while retaining high *ductility* beneath the hardened surface. This is a tough steel with the superior ability to *resist abrasion*. The more it is used, the harder and more polished the surface becomes. These are the characteristics of manganese steel that minimize wear and reduce the need for frequent lubrication.

The slow *crack propagation* rate of the steel allows for an *early discovery* of impending failure, even at arctic temperatures.



For a *complete technical discussion* of this high-strength "toughest steel known," write for *your* free copy of booklet, *Austenitic Manganese Steel*, Amsco Division, Chicago Heights, Illinois.

AMERICAN Brake Shoe COMPANY

AMSCO
American Manganese Steel Division
Chicago Heights, Ill.

Circle 616 on page 19

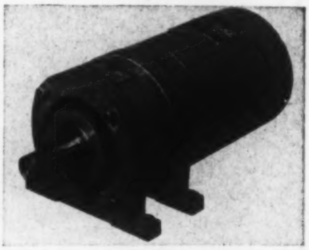
amplifiers operating from extremely small input signals. **Radio Corp. of America,** Semiconductor Div., Somerville, N. J.

*Circle 483 on page 19*

### Gear Assembly

**provides ratios to 20,000:1**

Compact in-line gear unit has high gear ratios and is suitable for connection to any make of standard flange-type motor without adaption changes. Range of ratios can be provided up to 266:1 in a single gear stage and up to 20,000:1 in two stages. Unit is furnished as a horizontal or vertical unit with output shaft pointing up or down. Present size range has capacities to 3000 lb-in. Unit has input and output shafts in line with the motor to provide compact assembly. **Odin Corp.,** Castleton, Indiana.

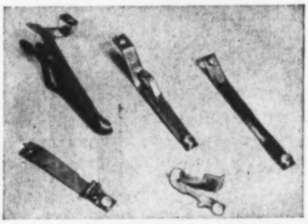


*Circle 484 on page 19*

### Copper Alloy

**has high resilience for spring uses**

Beryllium copper alloy has high fatigue strength, good resilience for spring uses and good electrical conductivity for parts such as switch components. Material, known as Berylco 10 alloy, is a relatively low beryllium content copper alloy (Be 0.5 per cent). Available in coiled strip form, ½-hard temper and heat treated to



Circle 617 on page 19→

DOW CORNING
CORPORATION

# Silicone News

## FOR DESIGN ENGINEERS

No. 33

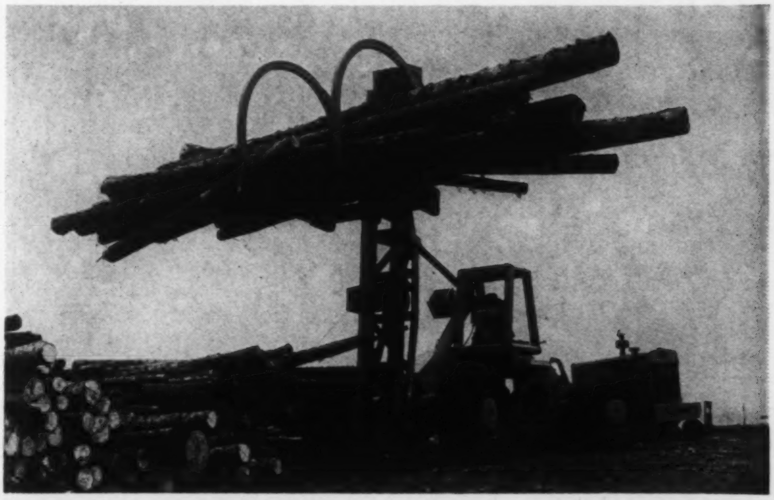
### Pump Life Tripled with Silicone Lubricant for Plastic and Rubber

**Chemically inert Dow Corning 3 Compound provides outstanding lubrication for moving plastic or rubber parts. Proof of its efficiency is provided by the Becher Pump Company, Chicago, Illinois.**

Becher produces a positive-flow chemical pump incorporating a nylon planetary roller plus a vinyl guard and tube. The pump is designed to carry chemical slurries, liquids or gases without danger of contamination or reaction.

By sealing the pump with Dow Corning 3, thus lubricating both plastic parts and sleeve bearing, Becher engineers tripled the unit's service life while reducing power requirements by 50%. They further report that introduction of the silicone compound so drastically reduced starting torque that they now employ a 1/25 hp, 1720 rpm shaded pole motor to do the work that previously required a more costly 1/12 hp split phase motor.

*(Cont. Pg. 2)*



## GIANT LOG STACKER ATTAINS GARGANTUAN POWER WITH SILICONE INSULATED MOTORS

**Engineers designing large electrically powered equipment are attaining more power per pound while gaining the many advantages of placing the power unit closer to the work by using motors insulated with Dow Corning Silicones. An excellent example is the giant Electric Log Stacker produced by R. G. LeTourneau, Inc., Longview, Texas.**

A separate high torque, a/c motor connects directly to every point of load — lift fork, hold-down tusks, boom tilt and rear axle steering. And there is a separate d/c motor inside each of the four rubber-tired drive wheels. A diesel-generator set supplies power to any or all motors on demand.

The work potential of these mechanical giants is worthy of Paul Bunyan. A single bite of the lift forks conveys up to 25 tons of logs; one stacker can move more logs

*(Cont. Pg. 2)*

### Coil Bobbins of Silastic Resist Unusually High Voltage, Temperature

**Combine high temperatures and high voltage and you'll quickly expose any weak link in an electrical insulation system. That's what happened when technicians at Transformer Engineers, Pasadena, California, tested conventional choke coils intended for use on aircraft fire control apparatus.**

The tests revealed that conventional coil bobbins all too often developed "electrical punctures" in the tube-to-flange joints when subjected to 15,000 volts at 140 C (320 F) operating temperatures.

The problem was overcome, however, with bobbins molded in one piece of Silastic, the Dow Corning silicone rubber. Featuring excellent thermal stability and dielectric strength after prolonged exposure to high temperatures, their one-piece construction avoided tube-to-flange joints entirely Over 3000 of them have been put into service in the last two years; not one failure has been reported to date. *No. 329*

### CLASS H MOTOR STILL ON TEST AFTER 60,039 HOURS AT 240 C

**At 10 A.M., June 6, 1946, a Class H insulated 10 hp motor was generator loaded to operate at its test temperature of 240 C in Dow Corning's motor test labs. Every 500 hours since it has been shut down and exposed to 100% relative humidity for 24 hours. As of 11 A. M. October 1, 1956, this motor was still on test after 60,039 hours at an average copper temperature of 240 C! That's equivalent to 367 years operation at the Class H temperature of 180 C.**

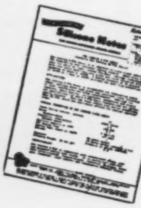
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE ☛

DOW CORNING
CORPORATION

# Silicone News

## DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



**Parts fabricated of Silastic are now available from over 150 companies listed in recently revised reference. Conveniently located in or near most industrial areas, these companies are equipped to fabricate Silastic parts to meet every requirement, including coated fabric, ducting and hose, extrusions, gaskets and seals, molded parts, O-rings, rollers, specialty and sponged parts, wire and cable.** ***No. 334***

●

**Documentary film "What's a Silicone?" available free of charge for showing to technical audiences. For more information circle** ***No. 335***

●

**Primers and Adhesives for Silastic are listed in a compact reference sheet that compares methods of application and recommended cure times, all in easy-to-read tabular form. A handy and valuable aid to designers and engineers in selecting the product best suited for a particular application.** ***No. 336***

●

**"Silicone Insulated Conductors," a reprint from WIRE AND WIRE PRODUCTS, describes and compares eight different types of silicone insulated wire and cable currently available for different applications.** ***No. 337***

●

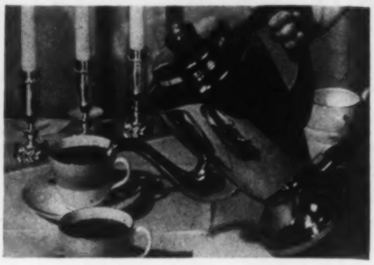
**Dow Corning Silicone Lubricants, including oils and greases, are described in a new, illustrated 8-page brochure that gives their properties, lists typical applications, and cites factors which contribute to obtaining longer life.** ***No. 338***

●

**All New — 1957 Guide to Dow Corning Silicones is a twelve page, fact-filled catalog which briefly describes the silicone products of interest to most industries. Containing latest data and information, the guide is designed expressly to help you enjoy the advantages, profits, and savings made possible through imaginative use of these unique engineering materials.** ***No. 339***

## Improve Percolator With Silicone Laminate At No Extra Cost

**Designers who make imaginative use of silicones to increase the life and reliability of toasters, steam irons, and other appliances can often do so without adding a single penny to the cost of the finished product. A recent example is provided by Aluminum Goods Manufacturing Company, manufacturer of Mirro-Matic Percolators.**



While Mirro-Matic's terminal pin insulators made of phenolic had proven satisfactory in normal use, the designers reasoned that abuse of the percolator could loosen electrical connectors and cause arcing. Phenolic is also prone to absorb moisture when splashed or dunked by careless users, raising a further possibility of insulator failure.

The risk of such breakdown, however, was entirely eliminated by the superior dielectric strength, heat and moisture resistance of silicone-glass laminates manufactured by Taylor Fiber Company. The moisture absorption of silicone laminate, for example, is only 0.02% compared with about 2% for phenolic.

And, because of the higher physical strength of silicone laminate, plain low cost stampings could be used instead of expensive molded parts. And they produced a further saving by reducing breakage during assembly.

The score: greater reliability for the Mirro-Matic Percolator without adding a cent to production costs! ***No. 330***

LOG STACKER *(Continued)*
in 5 minutes than three conventional yard lifts can handle in 30 minutes!

To provide maximum power and reliability every working motor — like all drive motors on all LeTourneau "electric wheel" equipment — is Class H insulated with Dow Corning Silicones. ***No. 331***

TRIPLE PUMP LIFE *(Continued)*
Dow Corning 3 Compound dissipates heat so effectively the pump remains cool even when pumping dry. No decrease in capacity or pressure has been noted after 3000 hours' operation at 1750 rpm. ***No. 332***

## SILICONE DAMPING FLUID KEEPS ACCELEROMETER ON THE "ALERT"

**Because Dow Corning Silicone fluids show little or no change in damping force over a wide temperature span, many engineers are utilizing them to produce performance features and economies not possible with organic damping oils. Here's how M. Ten Bosch, Inc., Pleasantville, N. Y. did it:**

Capitalizing on the inherent physical and chemical stability of Dow Corning 200 Fluid, Ten Bosch has designed an accelerometer weighing a mere 2½ ounces that retains a sensitivity of plus or minus .006 G at up to 6 Gravities. The time constant of the unit is only .0002, yet it has absolutely no undamped natural frequency.

Dow Corning 200 Fluid was selected as the "integrating fluid" for this unit after tests on dozens of other materials including motor oil, kerosene, mineral oil, water and air failed to meet Ten Bosch's requirements. Non-corrosive, non-conducting and non-gumming, the 200 Fluid permits the accelerometer to retain all of its original alertness and sensitivity over a wide temperature span in aircraft, missiles, and gyroscope direction service. ***No. 333***

**Dow Corning Corporation, Dept. 6812, Midland, Michigan**

| | | | | | |
|---|---|---|---|---|---|
| **Please send me:** | 329 | 330 | 331 | 332 | 333 |
| 334 | 335 | 336 | 337 | 338 | 339 |

NAME ______________________
TITLE ______________________
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*SILICONE NEWS is published for product design and development engineers by*

*first in silicones*

DOW CORNING CORPORATION
MIDLAND MICHIGAN

DOW CORNING SILICONES

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D.C. (SILVER SPRING, MD.)
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

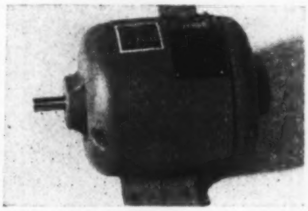
provide good electrical and mechanical properties, material withstands severe forming operations and stands up under repeated flexing in use. Tensile strength is 110,000 psi min; elongation in 2 in. is 5 per cent min; and electrical conductivity is 48 per cent IACS min. **Beryllium Corp.,** Reading, Pa.

*Circle 485 on page 19*

### Torque-Brake Unit

**provides torque range from 3.33 to 0.77 in.-lb**

Three compact torque-brake units give a wide range of speed-torque characteristics and are designed to provide continuous tension. Torque can be decreased by reducing the applied voltage or increased if intermittent ratings are permissible in the application. Three units provide torque at 2000 rpm of 3.33, 1.80 and 0.77 in.-lb. **B. A. Wesche Electric Co.,** 1622 Vine St., Cincinnati 10, Ohio.

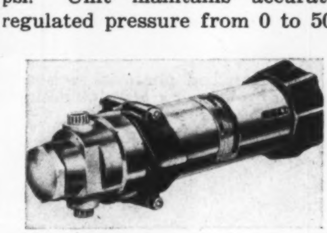


*Circle 486 on page 19*

### Pressure Regulator

**provides accurate pressure from 0 to 5000 psi**

High-flow regulator has wide range with normal inlet pressure of 6000 psi. Unit maintains accurately regulated pressure from 0 to 5000 psi. Burst maximum is 15,000 psi; maximum handle torque is 30 in.-lb; and unit is adaptable for use with air, nitrogen, helium, or gaseous oxygen. Unit is available in 1/4-in. tube straight-thread gasket



(*Continued on Page* 194)

something NEW!

CYL 2
CYL 1
a BETTER air valve

PATENT PENDING

. . . the SA series

**NEW SIMPLICITY** . . . a lapped spool sliding in a hardened sleeve provides the valving action—*One moving part.*

**NEW RELIABILITY** . . . the valve has no moving seals; eliminates wear, sticking, swelling of elastic seals. Gives positive, trouble-free performance.

**NEW RUGGEDNESS** . . . the SA Series sets new standards for long life. Outwears ordinary valves on every test.

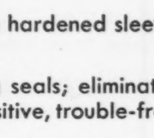
**NEW DESIGN** . . . full sub-plate mounting, watertight solenoid enclosures, integral junction boxes on all double solenoid models, side ports, bottom ports, O-ring manifold mount . . . all are standard on the SA Series.

The SA Series offers a complete line of actions, single solenoid spring return, double solenoid momentary contact and double solenoid spring centered 4-way actions . . . single and dual pressure versions. 54 different models in sizes 1/4" through 3/4" pipe. The most complete family of 4-way air valves available.

Get complete information and specifications by mailing the coupon.

**NUMATICS, Inc.** MILFORD, MICHIGAN

**NUMATICS Inc.**
**Dept. MD**
**106 Main Street**
**Milford, Michigan**



Send me your catalog No. 8000 on the new SA Series Valves.

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COMPANY____________________

ADDRESS____________________

CITY__________ZONE______STATE______

*Circle 618 on page 19*

# How to Control Corrosion on Bare Aluminum

Corrosion is a real threat to aluminum, especially to the higher strength alloys. It can be controlled by using a chemical surface treatment, with results as dramatically effective as those shown in the illustrations at the right.

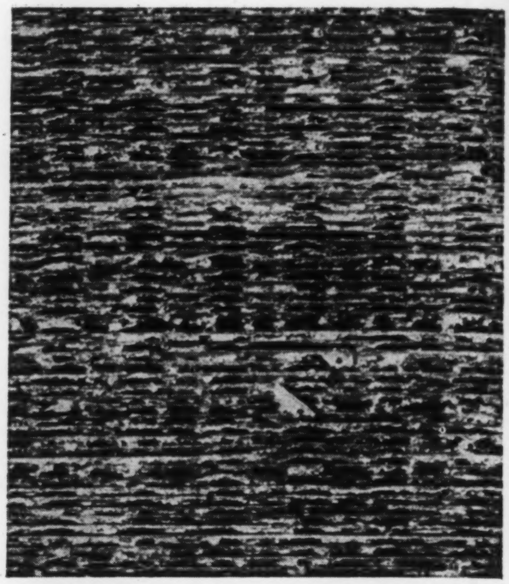
The corrosion protection is effected by Bonderite 710 or 720, applied by spray, immersion, or brush-on methods. A thin, iridescent coating, light to golden brown depending on the alloy treated, covers all surfaces of the aluminum and protects it against corrosion.

The coating produced by Bonderite is integral with the metal itself. It is flexible and can withstand moderate draws without difficulty. Arc and spot welding fabrication methods need not be changed, because the coating conducts electricity. It has good resistance to bimetallic and galvanic corrosion. Sheets, castings, forgings, extruded and rolled structural forms may be treated.

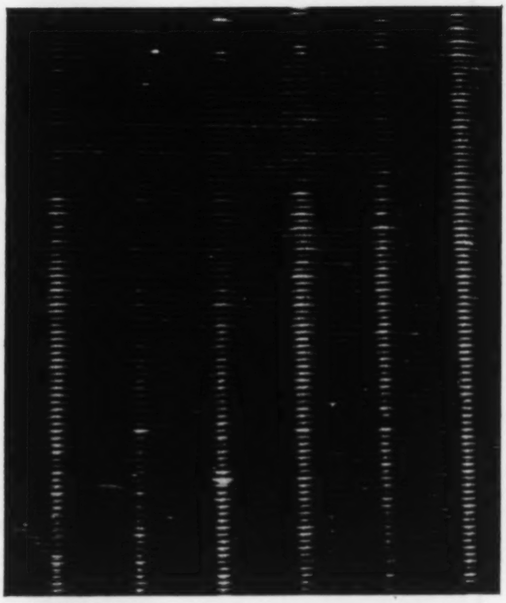
Bonderite 710 and 720 solutions are sludgeless, easily controlled, uniform in results.

These treatments may be used to increase the durability of paint finishes with equally outstanding effectiveness.

The Parker man in your territory has valuable experience to share with you in treating aluminum and its alloys. A letter or phone call will bring him to you.



**UNTREATED**—Unretouched photo of section of aluminum heat exchanger after 1150 hours in salt spray. Note corrosion.



**BONDERITE-TREATED**—Unretouched photo of section of identical aluminum heat exchanger after 1150 hours in salt spray. Note absence of corrosion.

*SINCE 1914—LEADER IN THE FIELD*

PROTECTED BY Bonderite PARKER RUST PROOF CO. QUALITY CORROSION RESISTANT

**PARKER** RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

**BONDERITE** corrosion resistant paint base

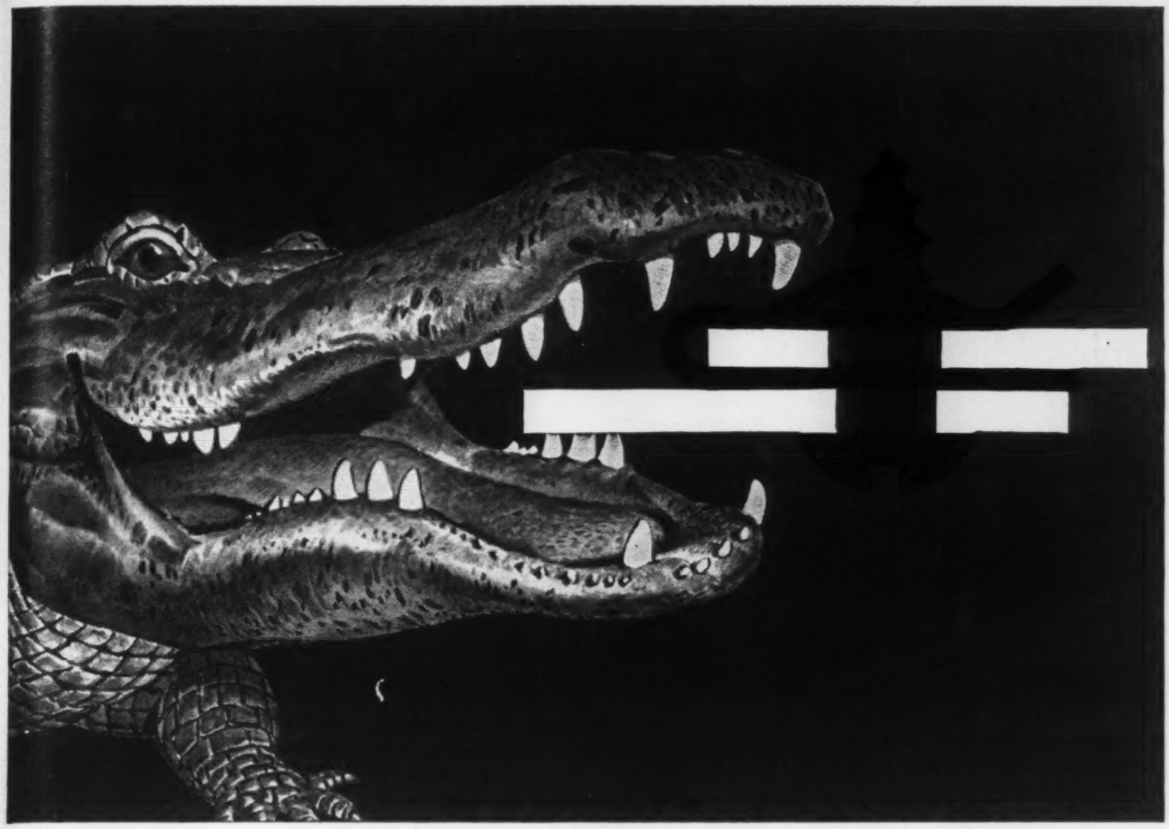
**BONDERITE and BONDERLUBE** aids in cold forming of metals

**PARCO COMPOUND** rust resistant

**PARCO LUBRITE** wear resistant for friction surfaces

**TROPICAL** heavy duty maintenance paints since 1883

*Circle 619 on page 19*



# STEEL JAWS THAT NEVER RELAX

## fasten a fastener in place

Alligator jaws have nothing on Tinnerman "U" and "J" type fasteners in gripping power. These fasteners press easily into locked-on position over panel edge or center panel locations. Yet they provide positive self-retention, ending the need for welding, staking or other secondary fastening devices. They are ideally suited for blind assembly or hard-to-reach locations.

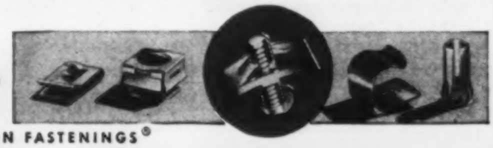
When combined with the familiar Tinnerman Speed Nut, this unique fastening principle provides a one-piece, self-locking, self-retaining fastener that is fast and easy to apply. The "U" or "J" feature can be combined with wire and tube retainers, latches, catches and a host of other fastening requirements to save time, material and production costs.

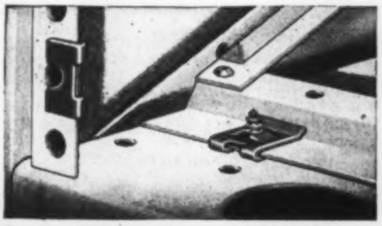
Find out about these and more than 8,000 other types of Speed Nut brand fasteners now serving industry all around the world. They can make important savings for you, can also simplify your assemblies. See your Tinnerman representative soon or write to us. **Tinnerman Products, Inc., Box 6688, Dept. 12, Cleveland 1, Ohio.**

**TINNERMAN**

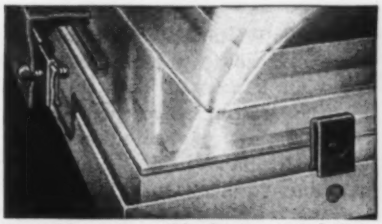
**Speed Nuts®**

FASTEST THING IN FASTENINGS®

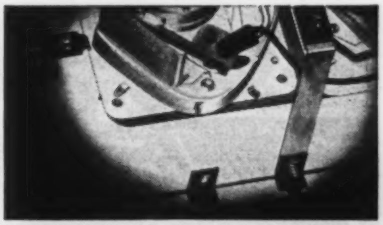




Greater flexibility for control equipment enclosures is provided by self-retaining "J" type Speed Nuts at 30% less production cost.



Assembly costs on this sheet-metal skylight frame are reduced 66% by Tinnerman "U" type Speed Nuts.



Gas range assembly costs are reduced 25% to 50% by using Tinnerman "U" and "J" type Speed Nuts.

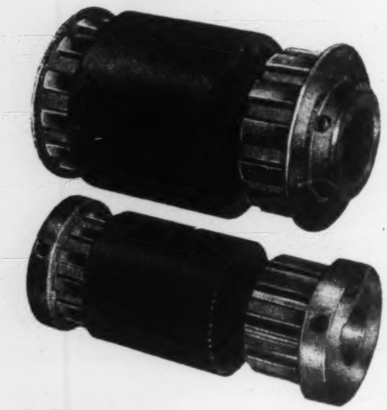
Circle 620 on page 19

NEW . . . NEW!

**Gear-Grip**

**Flexible Coupling**

**The most revolutionary design advancement for integral H.P. in a century!**

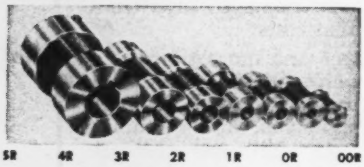


**Positive power transmission of rated load. Gear teeth on end casting match special rubber tube section.**

- Load ranges—2½ H.P. to 25 H.P.
- Shaft sizes—¾" to 1⅞".
- Specified lengths to design requirements.
- Prevents end thrust.
- "By Eye" shaft alignment.
- No lubrication required.
- Shaft Safety features.

**Dyna-Line . . .**

**The finest flexible coupling in single unit construction—specifically designed for fractional H.P.**



- True Flexibility and Torsional Resilience for quiet, load-plus power transmission without extreme deflection or twist.
- Lengths varied to design specifications in each series.
- Load ranges—1/15 to 1½ H.P.
- Shaft sizes — 3/16" to ¾".
- Lowest O.D. for highest torque capacity.

Write for Catalogs and Technical Bulletins.

Put a
GUARDIAN
Here
YOUR UNIT

Guardian
PRODUCTS CORP.
COUPLING DIVISION
DEPT. M-126, 1215 E. SECOND ST.
MICHIGAN CITY, INDIANA

*Circle 621 on page 19*

(Continued from Page 191)

seal or ¼-in. pipe thread. Internal valve and filter are removable without disturbing spring or diaphragm structure. **Accessory Products Corp.,** Dept. MD, 616 W. Whittier Blvd., Whittier, Calif.

*Circle 487 on page 19*

### Baking Enamel

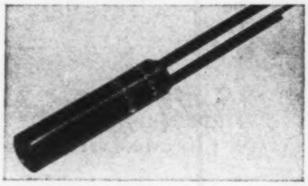
**one-coat material has high toughness**

Baking enamel coating looks and performs like porcelain. Known as Duracron, enamel is based on new series of thermosetting acrylic resins. It is adapted to finishing of heavy appliances and industrial products requiring toughness, mar resistance and durability. Comparative tests with alkyd-melamine enamels showed improvement in color and gloss retention on overbake, chemical and detergent resistance, humidity and salt-spray resistance, flexibility, hardness and mar resistance. Material provides full protection in one coat. **Pittsburgh Plate Glass Co.,** Industrial Finishes Sales Div., 632 Fort Duquesne Blvd., Pittsburgh 22, Pa.

*Circle 488 on page 19*

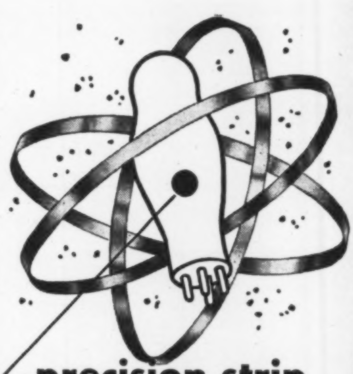
### Cartridge Heater

**delivers up to 200 watts per sq in.**



Electric cartridge heater for applications where temperature requirements are high and space is limited delivers as much heat as conventional heater five times its size. Fully insulated resistance wire is close to sheath, allowing rapid dissipation of heat through sheath. Ratings are 40 to 200 w per sq in. of heated surface. Unit is available in ⅜, ½ and ⅝-in. diam and in 1¼ to 10 in. sheath lengths. **Vulcan Electric Co.,** 85 Holten St., Danvers, Mass.

*Circle 489 on page 19*



**precision strip for electronics applications**

From 0.0005 in. to 0.040 in. thick and 0.090 to 6 in. wide, these alloys are available as special-tolerance strip:

**Beryllium Copper**
**Phosphor Bronze**
**Nickel Silver**
**Brass**
**Chromium Copper**
**Stainless 17-7PH**
**Invar**
**Magnetic: High Nickel**

Some immediately available. Others rolled to order in 2 to 21 days. Can be supplied in coils or straight lengths with slit or filed edges—also cadmium plated.

Write for Bulletin 7 TODAY.

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PRECISION PRODUCTS, INC.
501 Crescent Avenue • Reading, Pa.

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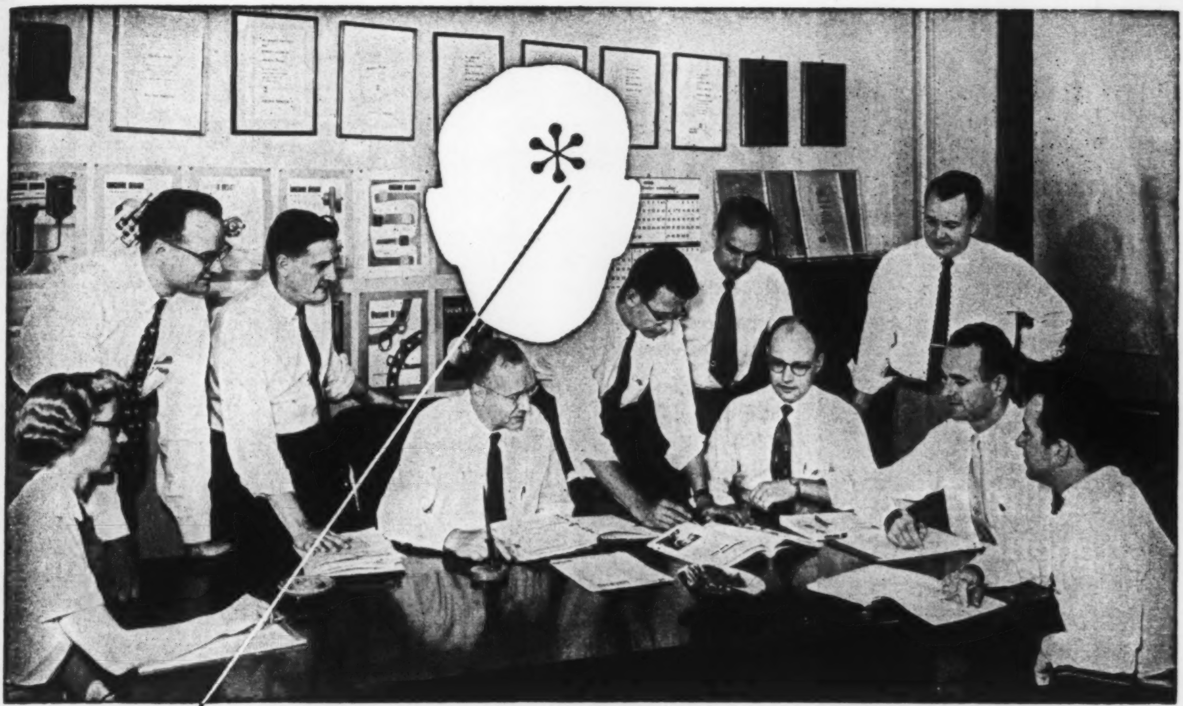
*Circle 622 on page 19*



*A Challenging Engineering Opportunity . . .*

# Technical Editor Wanted

- Here is your chance to gain a broad knowledge of the design engineering field and related activities.

- Edited for engineers, by engineers, MACHINE DESIGN has an opening on the editorial staff for a man with enthusiasm both for engineering and for writing and editing.

- He will work on a stimulating job that provides interesting contact with diversified problems in a variety of engineering areas.

- Additionally he will be encouraged to progress as a specialist in one or more of the branches of design engineering.

- He should have had some design experience, and an EE or ME degree would be desirable.

- He should be able to write fluently and well, and should show evidence of such ability.

- Duties include the procurement, selection, writing and editing of articles and feature departments.

- Headquarters are in Cleveland, with opportunities for travel to attend meetings and expositions and to seek material for publication.

- If you are interested and feel qualified, send full details of your engineering and writing experience to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

*Circle 623 on page 19*

When product designs for welded steel

Have twice the rigidty... three times the strength

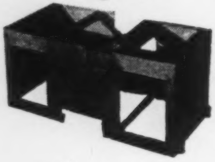
Yet require less material ...cost less to fabricate

WHY

aren't all your products designed for welding?

THE BETTER WAY
40% more rigid!

. . . yet this machine base of welded steel costs half as much as former cast iron designs.



*Ask*

THE LINCOLN ELECTRIC COMPANY
Cleveland 17, Ohio

*The World's Largest Manufacturer of Arc Welding Equipment*

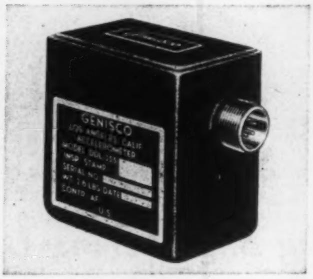
Circle 624 on page 19

# ENGINEERING DEPARTMENT EQUIPMENT

## Accelerometer

**has extreme resistance to vibration and shock**

Potentiometer-type accelerometer is a dual-damped low-range instrument with good resistance to severe vibration (withstands 10-$g$ accelerations from 10 to 1500 cps) and shock accelerations (to 40-$g$ shock of 5 miliseconds duration). Damping, 0.65 of critical at 75 F, is accomplished by use of a permanent magnet and silicon fluid. Range is $\pm 0.1$-$g$ to $\pm 8$ $g$, or up to $\pm 30$ $g$ with reduced damping. Unit will operate at temperatures from $-10$ F to $+$ 180 F, and offers linearity within 1 per cent of full scale. **Genisco, Inc.,** 2233 Federal Ave, Los Angeles 64, Calif.



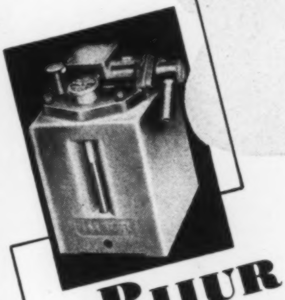
*Circle 490 on page 19*

## Sphere Grid

**speeds spherical drawing or measuring**

Sphere grid is a drafting underlay presenting an acurate, finely-divided grid of spherical coordinates. Unit combines scale, protractor, solver and ellipse guide, eliminating need for mathematical formulas or constructions. Device allows drawing accurate, measured pictorial spherical diagrams representing problems in solid geometry, gyroscopics, mechanical motion and military problems. Sphere and ellipse problems in engineering drawing and descriptive geometry may be solved without point-by-

YOUR SILENT PARTNER



BIJUR
AUTOMATIC LUBRICATION
HELPS YOU
• effect real savings in your own plant
• design savings into the equipment you make

Hand oiling is costly! It wastes time and money . . . steals valuable production hours . . . means extra down-time, fire risk, repair bills, replacement parts and causes product damage from excess lubricant.

But there's a way to end all this waste and worry. A Bijur Automatic Lubrication System never forgets a bearing . . . bearings never are thirsty for oil, never flooded. Lubrication is continuous, exactly right. All the hazards of hand oiling are banished—*automatically!*

Bijur Systems are custom-engineered for machinery used by practically all industries. Every bearing receives a clean supply of oil at the right time . . . automatically and correctly metered to suit its individual needs . . . while the machine is running! Whether for new equipment you *buy*, or machines you *build*, insist on Bijur. It's better—*by design!*

P-5

BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey
*Pioneers in Automatic Lubrication*

Circle 625 on page 19

a new material

**JUST PUBLISHED!**

*New 24-page brochure gives complete engineering data*

# Here's the story of fatigue-proof T.M. steel bars

**MADE BY THE e.t.d. PROCESS**

*Elevated Temperature Drawing*

*a **new** material—made by*

*a **new** process—with*

*a **new** combination of properties*

- **High Strength**
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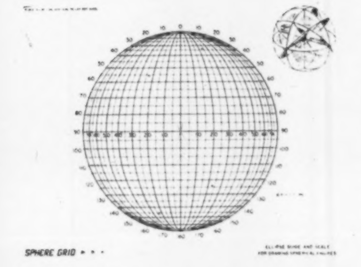
**Circle 626 on page 19**

point plotting or intersection methods. Foreshortening along isometric, dimetric, trimetric and non-isometric axes may be computed



without formulas or box constructions. **Sphere Grid Sales,** 3829 Davis Place N.W., Washington 7, D. C.

*Circle 491 on page 19*

## Microfilm Reader

**enlarges and prints copy up to 14 by 14 in.**

Microfilm reader makes large prints by direct projection of the film image on photocopying paper. Desk-top unit serves as a viewer and printer for aperture cards or jacket cards. Viewing and printing screen is 14 by 14 in., making unit suitable for general business operations in which enlargement is required. By use of interchangeable lens, unit will provide magnifications from 15X to 42X. Overall dimensions of unit are 30 in. high with 17 by 17 in. base. **Dexter Folder Co.,** Filmsort Div., 50 S. Pearl St., Pearl River, N. Y.

*Circle 492 on page 19*

## Oscillograph

**direct-recording unit has high sensitivity**

Dynamic recording oscillograph produces instantly-readable records, combining high-frequency and sensitivity characteristics of photographic oscillographs with con-

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Circle 627 on page 19

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*Circle 628 on page 19*

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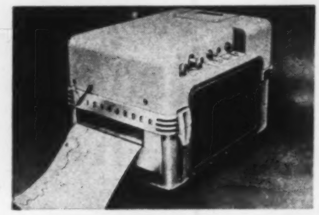
Circle 629 on page 19

venience of direct-writing instrument. No powder magazines or other processing material is required. Flat frequency response of 200 cps is achieved without peaked amplifiers or other compensation. Unit accommodates up to six channels; each with full 6 in. deflection, and traces may overlap. Chart speeds are 0.2, 1, 5 and 25 in. per second, minute, or hour. Instrument accommodates 100 ft of record, may be loaded in daylight, and has indicator showing amount of unused record. Unit operates on 115 v, 60 cycle. **Minneapolis-Honeywell Regulator Co.,** Heiland Div., 5200 E. Evans Ave., Denver 22, Colo.

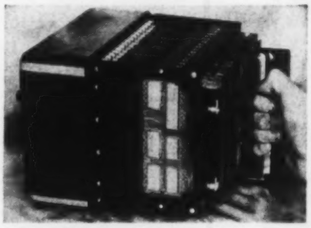


Circle 493 on page 19

## Arithmetic Control

**digital unit has plug-in circuit cards**

Computing unit operates on 3 v potential and employs direct-coupled circuitry, thereby eliminating many components normally required. Unit contains nearly 1000 transistors, 300 resistors, and 12 capacitors permanently dip-soldered into compact, plug-in, printed-circuit cards. Each card provides all necessary functions for one binary digit including add, subtract, multiply, divide, square root, shift right, shift left, sign magnitude and absolute magnitude. Ten "math" cards and seven "control" cards are plugged into 10 in. long unit. Instrument adds two numbers in 1.5 mu sec and



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Circle 630 on page 19

# Why close tolerances in resilient gaskets are rarely necessary

Tolerances in the size and shape of a gasket do not become critical if the material chosen seals effectively over a wide range of compressions.

Armstrong Cork-and-Rubber Compounds are typical of such wide range materials. They seal tightly under compressions ranging from 20% to 33%. As a result, tolerances in the size of the gasket can be as wide as ±.010". In some applications, the wider tolerances permissible with compressible gasket materials may effect savings in machining time.

## Confined applications

Cork-and-rubber's wide compression range—and the resultant wide tolerances possible—is particularly valuable in confined gasket applications. Because these materials are truly compressible, they decrease in volume under load. This enables cork-and-rubber gaskets made slightly oversize to compress into a completely confined space. The absence of side flow makes it easy to mate flanges perfectly.

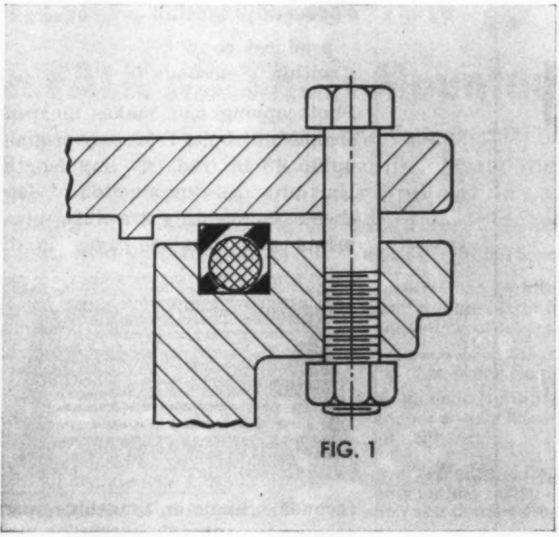
FIG. 1

Figure 1, for example, illustrates the relative sizes of a cork-and-rubber gasket and a comparable non-compressible molded ring. The resilient cork-and-rubber compound permits wide tolerance in its size, whereas the molded ring must be made to very close tolerances to allow perfect fit between the flanges.

Similarly, in figure 2, wide tolerance cork-and-rubber gaskets make an effective packing ring. Their true compressibility controls lateral flow and prevents excessive build-up of radial pressure on the shaft.

## Metal-to-metal joints

When non-compressible rings were used on the flanged journal of the calender roll shown in figure 3, extremely close tolerances were required. Undersized rings leaked. Oversized rings prevented metal-to-metal contact between the flanges and caused misalignment. Both of these problems were solved with the use of standard tolerance cork-and-rubber rings, which fitted perfectly and sealed tightly.

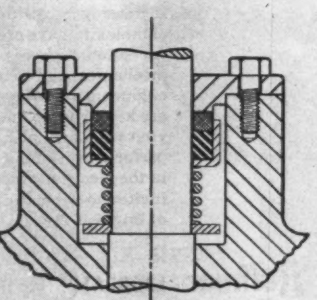
FIG. 2

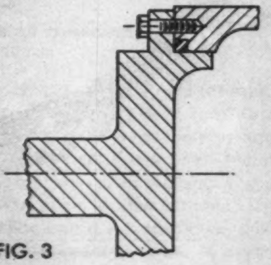
FIG. 3

We recommend that you discuss specific sealing problems with an Armstrong representative. Methods and materials he may suggest may help you reduce production time and lower costs.

**SEND FOR 24-PAGE GASKET MANUAL**

*You'll find other useful information on the design and use of gaskets in the new Armstrong Gasket Design Manual. Write for your copy of this manual to Armstrong Cork Co., Industrial Division, 7112 Dean Street, Lancaster, Pa.*

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Circle 632 on page 19

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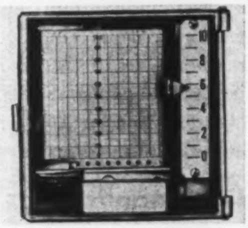
multiplies in 15 mu sec. Units with larger digital capacitities may be constructed by increasing number of plug-in cards. **Philco Corp.**, 4700 Wissahickon Ave., Philadelphia, Pa.

*Circle 494 on page 19*

## Recording Potentiometer

### with either ac bridge or potentiometer circuitry

Miniature self-balancing electronic recording potentiometer gives a continuous record on a 3 in. strip-chart. Available in either potentiometer or ac bridge models, instrument can be used to measure and indicate or record any variable which can be converted into an electrical quantity. **Bristol Co.**, Waterbury 20, Conn.

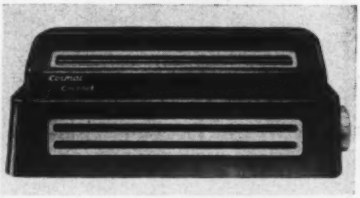


*Circle 495 on page 19*

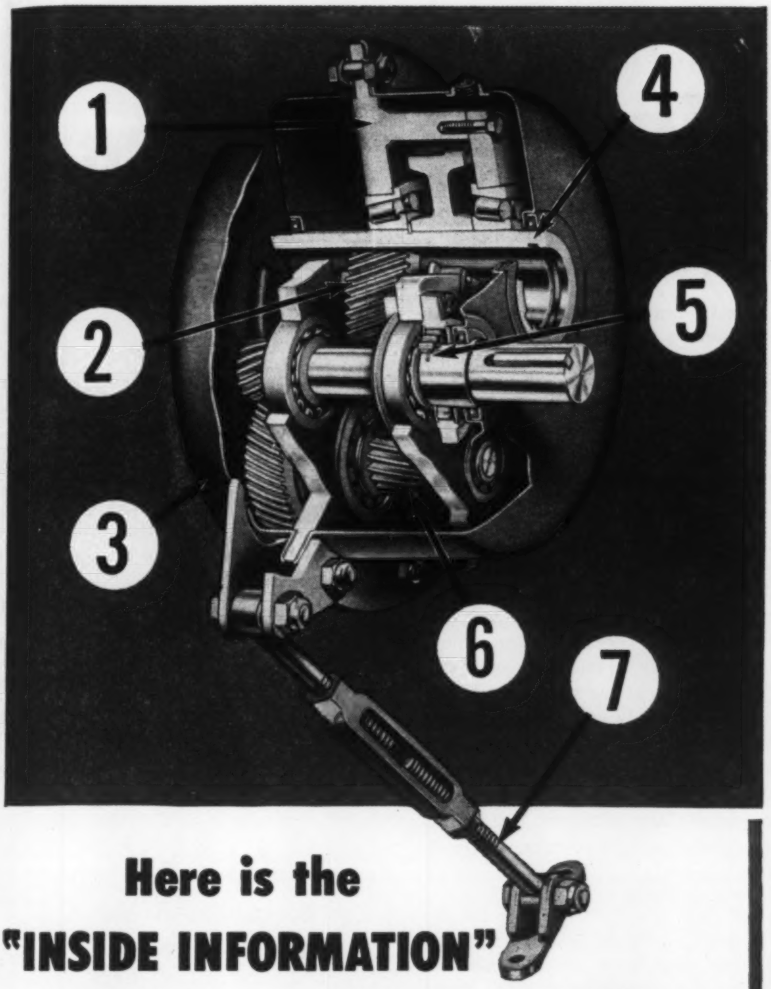
## Photocopying Unit

### produces copy within 19 seconds

Photocopying unit makes inexpensive, exact copies from any original up to 18 in. wide by any length. Unit provides reproduction of data sheets, engineering drawings, blueprints and catalog pages in 19 seconds. Single-unit machine operates under any office lighting conditions, from subdued incandescent to full daylight. Housing is soilproof, corrosionproof acrylic plastic; total weight is 29 lb. **Cormac Industries Inc.**, 80 Fifth Ave., New York, N. Y.



*Circle 496 on page 19*



# Here is the "INSIDE INFORMATION" on FALK *ALL-STEEL* Shaft Mounted Drives

Take a careful look inside the Falk all-steel Shaft Mounted Drive, and you will know why this newest member of the famous Falk family is ideal for applications where direct mounting on the driven shaft is desirable. It is the only drive in its field with all these superior "In-built" factors:—

1 **All-steel Frame,** with more than double the rigidity of iron, supports all rotating elements.

2 **Precision Helical Gears,** designed and machined by Falk, rated to AGMA standards.

3 **Pressed Steel Housings,** whose sole function is to keep oil in, dirt out; easily removed for gear inspection without dismounting unit.

4 **Through Hollow Shaft** with counter bore provides for easiest installation or removal from driven machine shaft extensions.

5 **Backstop** can be furnished with the unit or added later for positive prevention of reverse rotation.

6 **Positive Lubrication,** continuous direct dip of revolving elements at all speeds.

7 **Tie Rod** and turnbuckle serve as anchor and facilitate V-belt or chain adjustment.

*Write* to Department 247 for engineering bulletin, including selection and dimension details.

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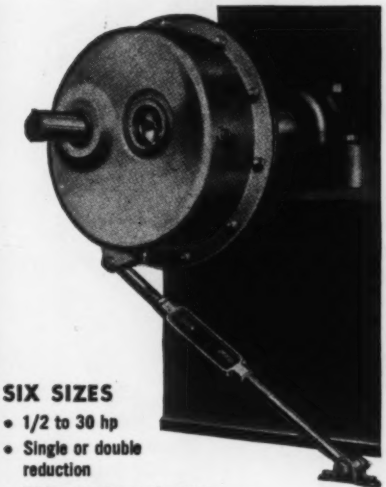

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- 1/2 to 30 hp
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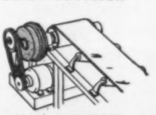
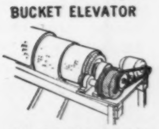
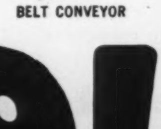
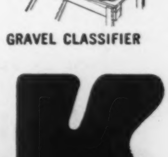
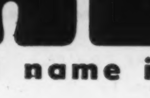
### A FEW TYPICAL APPLICATIONS


APRON FEEDER


LINE SHAFTING


SCREW CONVEYOR


BUCKET ELEVATOR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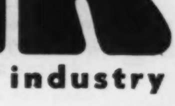
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**The Design and Conduct of Human Engineering Studies.** *By Alphonse Chapanis, professor of psychology and industrial engineering, John Hopkins University; 73 pages, 8½ by 11 in., paperbound; published by and available from San Diego State College Foundation, San Diego 15, Calif.,* $2.00 *per copy.*

This booklet presents the results of studies in this relatively new field. Subjects covered include methods of observation, methods for study of accidents and near accidents, experimental methods, psychophysical methods and statistical methods with summarizing, interpreting and experimental data. The book concludes with a discussion of some special problems of experimenting with people, including selection of subjects, methods, and apparatus.

**Contracts, Specifications and Engineering Relations.** *By Daniel W. Mead; 427 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co.,* 330 *W. 42nd St., New York* 36; *available from* MACHINE DESIGN, $7.00 *postpaid.*

This book discusses legalistic relations for the engineer. Among the subjects covered are ethics, law, contracts, specifications, and the writing of technical reports and business letters. The specifications section is based on actual specifications currently in use. The chapters dealing with legal matters cover general relations, rights and responsibilities of engineers.

**Application of Strip Springs to Instrument Design.** 24 *pages, 6 by 9½ in., paperbound, side-stapled; published by and available from Department of Scientific and Industrial Research, Charles House, 5-11 Regent St., London S. W. 1; 36c per copy.*

This booklet provides designers with information concerning appli-

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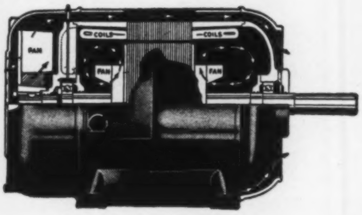

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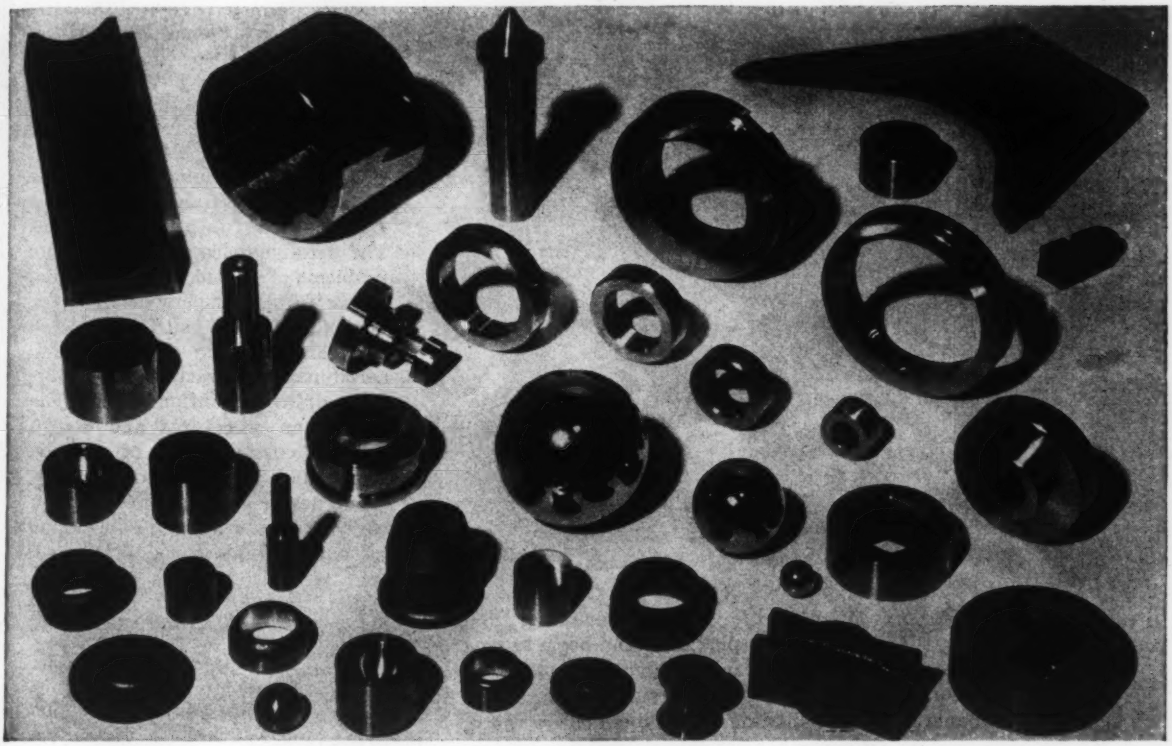

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cations of strip springs for instrument and other light-duty purposes. Discussed are the functional principles, suggested applications, and mathematical and design data.

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**Aerodynamics, Propulsion, Structures and Design Practice.** *Edited by Grayson Merrill, Captain, USN, navy technical director, Jupiter Ballistic Missile Project, Bureau of Ordnance; 595 pages, 6 by 9 in., clothbound; published by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, *$10.00 postpaid.*

This second volume in the series of Principles of Guided Missile Design is divided into three sections. The aerodynamics section presents problems of guided missiles, nature of air flowing supersonically over bodies and control surfaces, rocket and air-breathing engines, and aerodynamic characteristics of various airframe configurations. The section on structures and design practice covers design of the airframe and packaging of its contents, design criteria, environmental loads, materials and fabrication methods.

## Association Publications

**Criteria for Professional Employment of Engineers.** 23 *pages,* 5½ *by* 8½ *in., paperbound, side-stapled; published by and available from National Society of Professional Engineers, 2029 K St. N.W., Washington 6, D. C.; free to members, 25c per copy to non-members.*

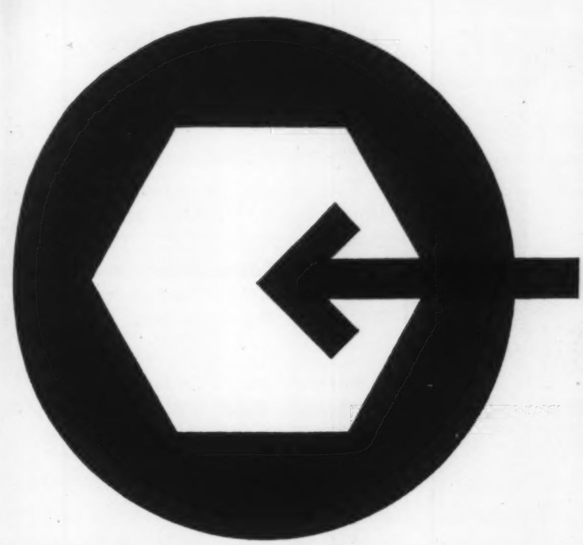
Printed in check-list form, the criteria cover specific categories of engineering career development. The criteria suggest the responsibilities of the employer to his professional employees, and the latter's responsibilities to the employer. Topics include recruitment, indoctrination, professional development of the individual, salaries, engineering titles, personnel practices, and termination practices.

①

## Government Publications

**Directory of National Trade Associations.** 37 *pages, 8 by 10 in., paperbound, side-stapled; published by U. S. Department of Commerce,*

have



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Sold only through authorized Holo-Krome distributors.

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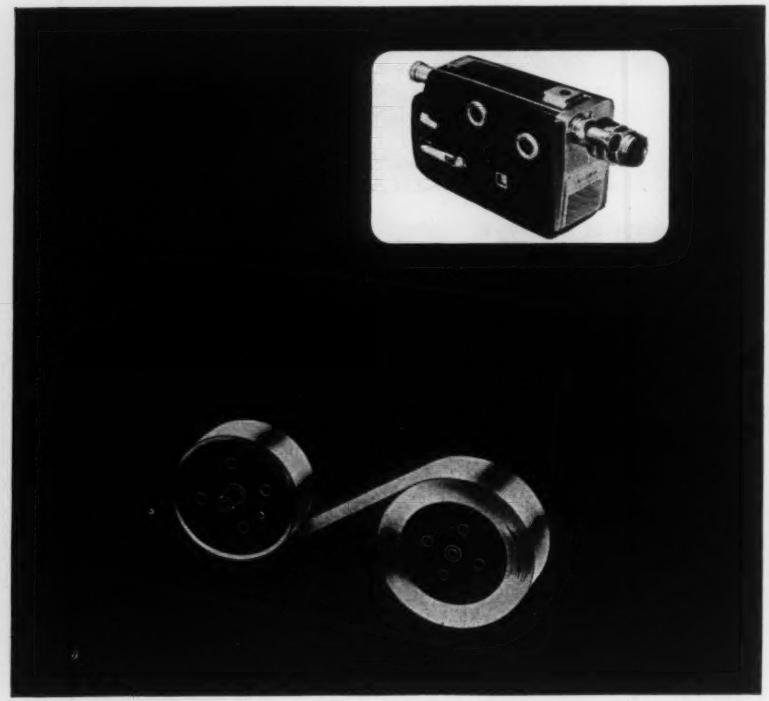

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**USING A NEG'ATOR® SPRING**

Using the NEG'ATOR constant-tension spring, a powerful long-running motor can be made by winding the NEG'ATOR band on a storage drum then *reverse-bending* the free end around a larger, output drum. The tendency of the material to recurl to its *preset curvature* around the smaller drum imparts a more constant output torque to the shaft of the output drum.

As the illustration shows, Eastman Kodak engineers have designed a NEG'ATOR Spring motor and have applied this motor to their new 16 mm Cine-Kodak K-100 Movie Camera. In this application, the NEG'ATOR motor drives the film and provides much longer film footage per wind than is possible with a conventional power spring—40 feet of film per wind, 100 seconds of exposure at the normal 16 frames per second speed.

By using a NEG'ATOR Spring as shown, Eastman Kodak's engineers obtained advantages in addition to longer film footage. The motor eliminates extreme torque variation and wasteful high torque output at full wind. It cannot "jump" or "skip" (solving a major camera-drive problem). It simplifies design of gearing and governor, requires no lubrication, permits full utilization of the work potential of the spring, and reduces over-all cost.

Used as a motor, as shown, or as a constant-tension extension member, a band, clamp, or clip, the NEG'ATOR might be just what you're looking for. You can learn more about the NEG'ATOR by reading Bulletin 310N which is available on request. Or write on your company letterhead for a sample NEG'ATOR Spring.

THE HUNTER
neg'ator
constant-force spring

**HUNTER SPRING COMPANY**
*3 Spring Avenue, Lansdale, Pennsylvania*
SPRINGS • STAMPINGS • TEST APPARATUS

*Washington D. C., and available from Department of Commerce Field Offices; 40c per copy.*

This booklet lists over 2000 national trade, business and professional organizations. The book lists 65 engineering associations alone. A complete index and finding guide are included.

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**3768. On Possible Similarity Solutions for Three-Dimensional Incompressible Laminar Boundary Layers; I-Similarity with Respect to Stationary Rectangular Coordinates** — 30 pages.

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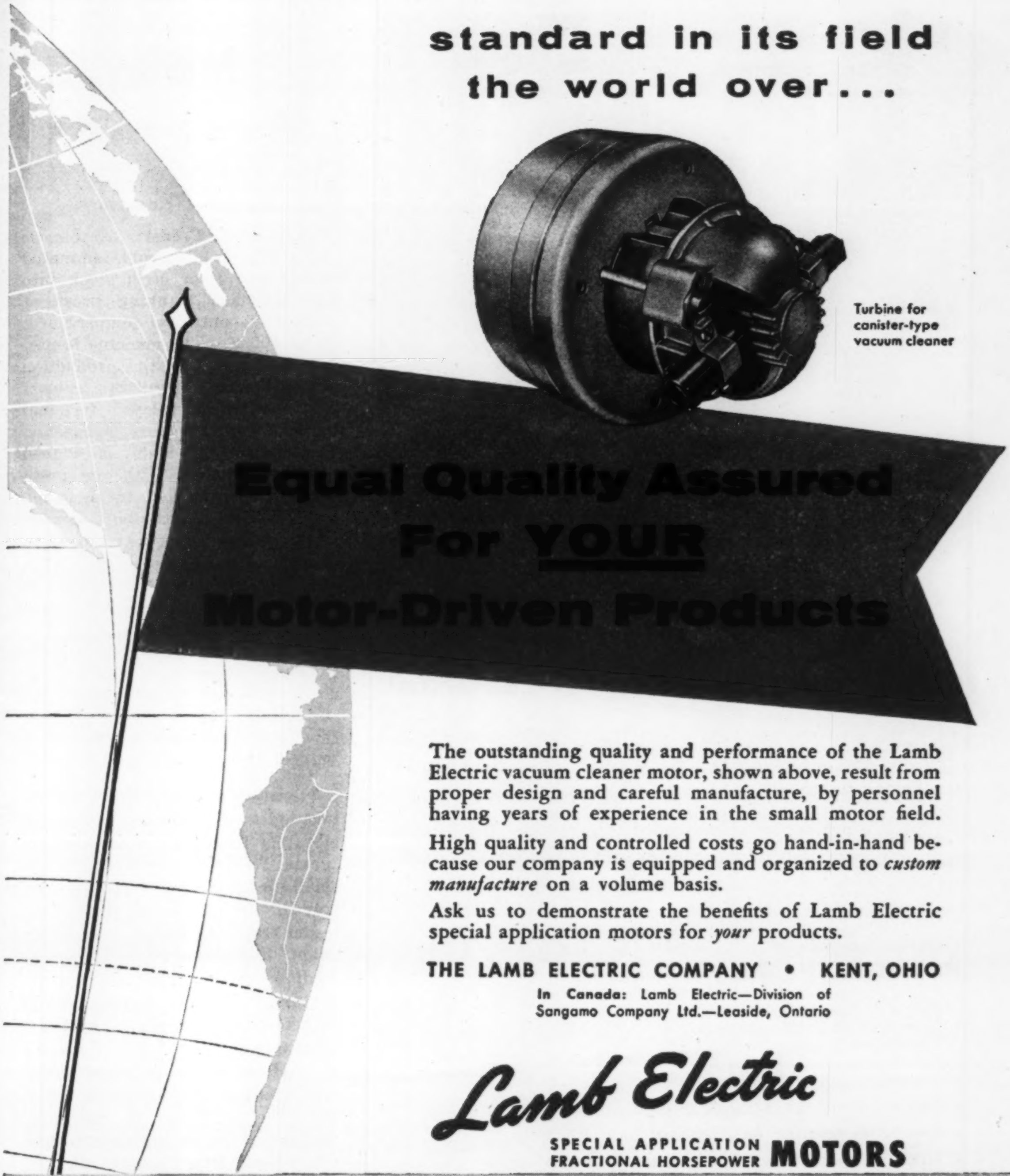

Turbine for canister-type vacuum cleaner

The outstanding quality and performance of the Lamb Electric vacuum cleaner motor, shown above, result from proper design and careful manufacture, by personnel having years of experience in the small motor field.

High quality and controlled costs go hand-in-hand because our company is equipped and organized to *custom manufacture* on a volume basis.

Ask us to demonstrate the benefits of Lamb Electric special application motors for *your* products.

**THE LAMB ELECTRIC COMPANY • KENT, OHIO**

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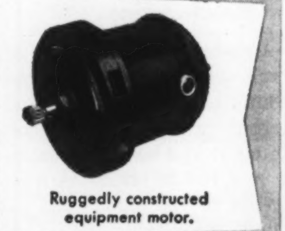
**Lamb Electric**

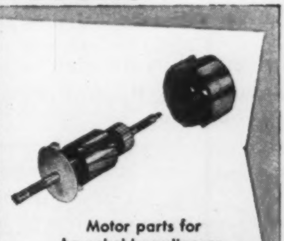
**SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS**



Ruggedly constructed equipment motor.

Lightweight motor for portable devices.

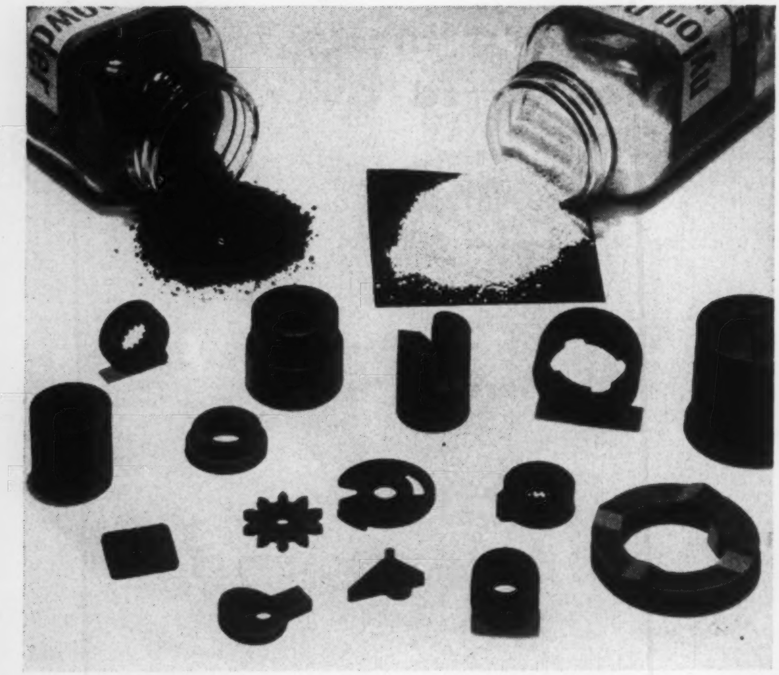
Intermittent high torque aircraft motor.



Motor parts for household appliances.

**If you are interested in any of the above motors write and we shall be glad to send full information.**

*Circle 639 on page 19*



## New Nylasint® 64 nylon wear parts ... tough, durable, impact-resistant

Nylasint 64 is the newest in the family of Nylasint finely divided nylon powders, bringing new advantages to wear parts formed by the technique of cold pressing and sintering.

Nylasint powders, which can be compounded with various fillers such as molybdenum disulphide or graphite, form parts with these superior properties:

- *High wear and abrasion resistance*
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- *High modulus—resist deformation under load*
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- *High heat distortion temperature*

... plus these advantages in processing:

- *Uniform shrinkage, accurate profiles*
- *Require no degating, have no flash lines*
- *Minimized possibility of stress spots or internal strain*
- *Economical mass production*

For detailed information on your applications, write to National Polymer Products, Inc., Reading, Pa.

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POLYPENCO

NATIONAL POLYMER PRODUCTS, INC.
A Subsidiary of The Polymer Corporation
Reading, Pennsylvania

Circle 640 on page 19

# New Machines

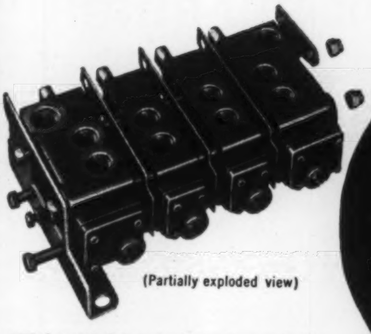
### Materials Handling

**Strip Stock Feeder:** Automatic unit feeds hot or cold laminated plastic and fiber strip stock into any standard blanking press at uniformly controlled temperatures up to 300 F. The machine is particularly useful in the production of parts such as resistors, capacitors, switches, relays, terminal blocks, printed boards and gears. The strip stock rests on a feed belt synchronized with the press through a crank arm to an indexing roll feed. As the bottom strip leaves the machine, the strip above drops into place. Positive butting of the ends reduces the number of partially blanked pieces. An electric heating system, regulated by thermostatically controlled heating elements, brings the stock to desired blanking temperature and maintains it uniformly. *Technical Design & Development Co. Inc., Milford (Devon), Conn.*

**Vibratory Feeder:** FE ¼ miniature electro-permanent magnetic vibratory feeder is designed for accurate feeding operations where small amounts of materials are involved. It can be supplied with feeder trays of various types which adapt it to operations such as feeding single units at a time, bagging, bottling, and adding reagents to chemical systems. Feed rate is controllable to a maximum of 500 lb per hr (sand). The unit operates directly from 115 v, 60 cycle, ac line. It measures 10¾ x 5 x 6⅛ in. high and weighs 7 lb. *Eriez Mfg. Co., Erie, Pa.*

### Metalworking

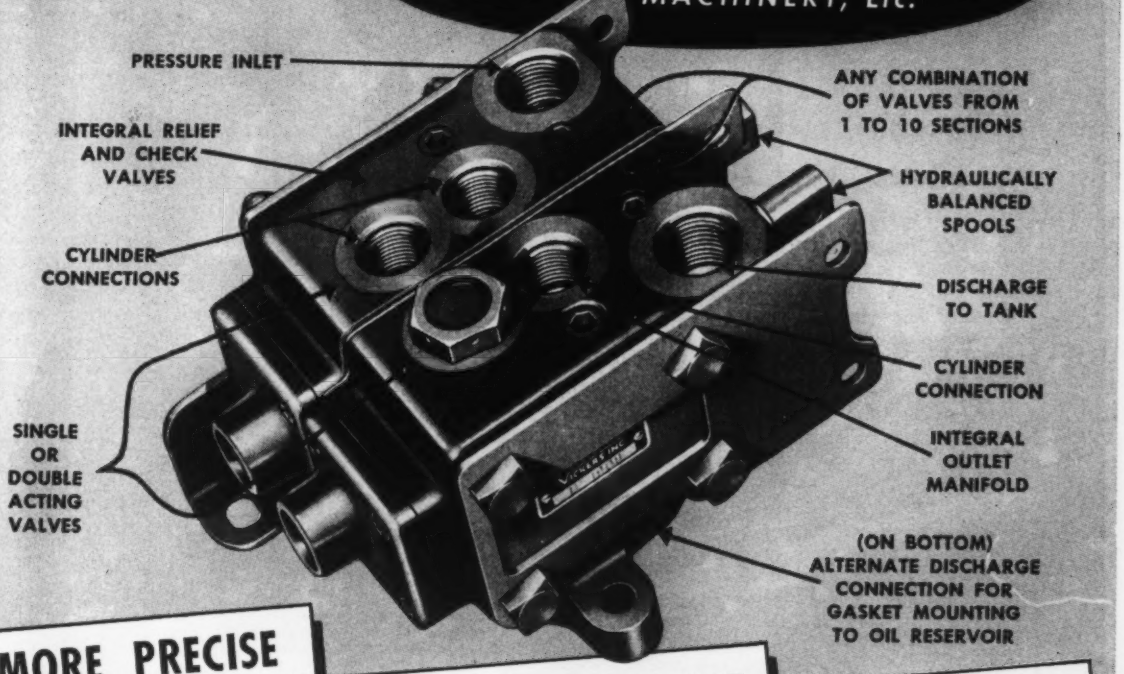
**Gear Grinder:** Model 140 reciprocating precision gear grinding machine is designed for grinding external precision spur gears and both right and left-hand helical gears from 8 to 100 pitch. A number of gears of the same type can be ground simultaneously from hardened steel in preformed or solid blanks, or gears can be ground individually. The grinder


(Partially exploded view)

"O" ring seals between valve sections seal with pressure to form positively leak-proof joints.

# Series CM11 VICKERS® MULTIPLE UNIT VALVES

For *MATERIALS HANDLING EQUIPMENT, FARM TRACTORS, BUCKET LOADERS, CONSTRUCTION and MINING MACHINERY, Etc.*


PRESSURE INLET
INTEGRAL RELIEF AND CHECK VALVES
CYLINDER CONNECTIONS
SINGLE OR DOUBLE ACTING VALVES
ANY COMBINATION OF VALVES FROM 1 TO 10 SECTIONS
HYDRAULICALLY BALANCED SPOOLS
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(ON BOTTOM) ALTERNATE DISCHARGE CONNECTION FOR GASKET MOUNTING TO OIL RESERVOIR
VICKERS INC

## MORE PRECISE CONTROL

Improved Metering Characteristics

## REQUIRES LESS SPACE

New Combination Operating-Valve and End-Plate Sections

## LOWER COST

Simplified Design and Construction

This is a more compact and versatile design of valve. End sections combine in one casting the inlet or outlet manifold plate together with any operating-valve section. Inlet section also contains relief valve. Individual outlet plates available for single unit valves. Single- and double-operating valve sections can be added between end sections as needed. Valve can be adapted for tandem (series) operation. Single-acting valves available for either direction of lever shift.

Other features include protection of pump from reverse flow during shifting . . . three point mounting for more simple installation . . . cylinder connections with ¾-16 N.F.-2 straight threads (AND 10050 type) help insure leak-proof connections . . . optional outlet ports in end section so valve can be gasket mounted to the oil reservoir or pipe connected. Designed for use with Vickers Series V-200 Vane Pumps (up to 11 gpm), the CM11 Valve can be used up to 2000 psi working pressure. For further information write for Catalog No. M5101-A.

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*ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921*

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## "This Torrington design solves my bearing problem!"

Time and again, industrial firms with special bearing requirements turn their assignments over to Torrington—specialists in designing and building custom bearings.

This confidence has been won by years of successful experience. When you call on Torrington, you engage engineers who have devoted tens of thousands of hours to the design and construction of virtually every type of bearing. From their experience—and imagination—comes the *special* bearing that will bring you peak efficiency, service life and economy.

For a custom *or* standard bearing—any size, any type—you can rely on the skill and experience of Torrington.

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South Bend 21, Ind. • Torrington, Conn.
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**TORRINGTON BEARINGS**

**Spherical Roller • Tapered Roller • Cylindrical Roller**
**Needle • Ball • Needle Rollers**

*Circle 642 on page 19*

accommodates a maximum work size of 8 in. OD by 5 in. face width. Maximum length between centers is 15 in. Change gears permit the number of teeth ground to range from 4 to 192. Maximum helix angle adjustment of wheelhead is 45 deg right and left hand. Grinding wheel is mounted on a precision preloaded ball-bearing spindle. Spindle speed is 2100 rpm. Electrical and hydraulic units conform to JIC standards. *Sheffield Corp., Dayton, O.*

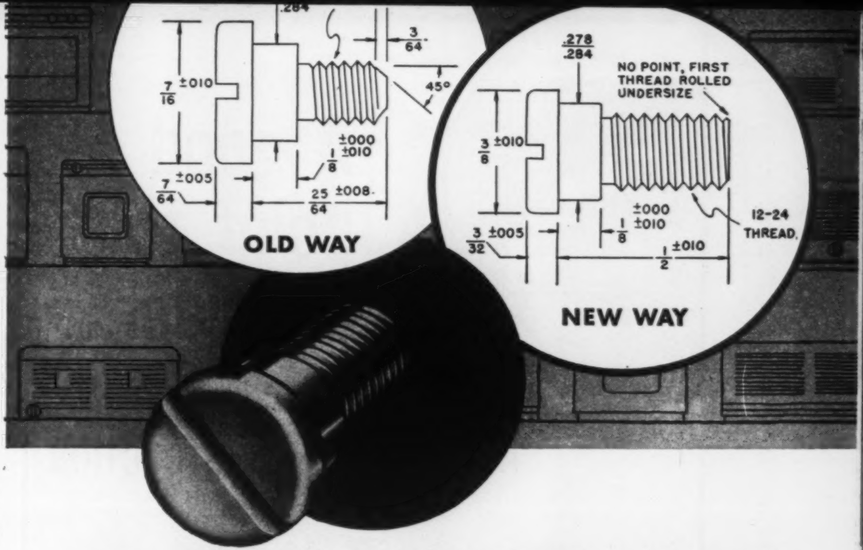
**Portable Nibbler:** New tool cuts 16 gage corrugated sheet metal at a rate of 33 in. per minute. It also cuts small diameter duct or sheet metal pipe without distorting, curling or flattening of the corrugated curves on either side of the cut. Nose piece and die holder are set at right angles to the body, permitting easy handling of the tool. Diagonal cuts across the curves can be made, and circles as small as 2 in. in diameter can be cut. The unit weighs 7½ lb and is 10 in. long. It has a ½-hp high-speed motor and operates from 110 v ac/dc current, single phase. *Fenway Machine Co., Philadelphia.*

**Jig Borer:** Starrett optical jig borer has spindle speed range from 70 to 1300 rpm. The unit includes an electric motor and controls, work light, foot pedal, covered table prismatic guides, scales for reading rapid travel of table, and control panel with indicating light and emergency stop. Working surface of the table is 35½ x 12½ in. Longitudinal travel is 19⅝ in.; cross travel, 12½ in.; vertical spindle travel, 7⅞ in. *Aaron Machinery Co. Inc., New York.*

## Processing

**Portable Welder:** R-500 portable welder, equipped with double-pole and single-pole electrode gun, is designed for aircraft applications such as the repair and production of stainless steel-fiberglass insulating blankets and shrouds in thicknesses from 0.002 to 0.020-in. The single-pole gun can be used easily where space limitations prevail, and produces one weld during its operation. Double-pole gun per-

Circle 643 on page 19→



**Townsend Design Service Reduced Cost of This Part from $10 to $5 per Thousand**

The two parts shown above demonstrate how Townsend engineers saved an appliance manufacturer $5.00 per thousand by redesigning a special fastener so that it could be produced by cold-forming. By redesigning this part a costly machining operation was eliminated.

The shouldered screw at left, above, an integral part of a major appliance, was originally produced by another method at a cost of about $10.00 per thousand. Townsend engineers applied their extensive knowledge of cold-forming techniques to the problem and by slightly changing the design found that the part could be produced for about $5.00 per thousand—a clear savings of 50% on a part used in great volume. The new part shown at right provides just as efficient a fastener as the old.

This is a typical example of how the Townsend Technical Sales Department can help you in your efforts to improve your products and reduce assembly costs. These men can serve you in several ways—they will act as fastening consultants to your design and production engineers—they will design special parts or recommend the best standard fasteners. They often study an entire assembly procedure and suggest improved techniques.

The Technical Sales Department has back of it a company with nearly a century and a half of wire drawing and cold-forming experience. Townsend regularly produces more than 10,000 standard and special parts and fasteners—has the capacity to manufacture more than 60-million pieces a day.

To learn how you may use Townsend services to effect substantial savings in material costs, speed production and improve your products, write today for illustrated bulletins or use the coupon below.

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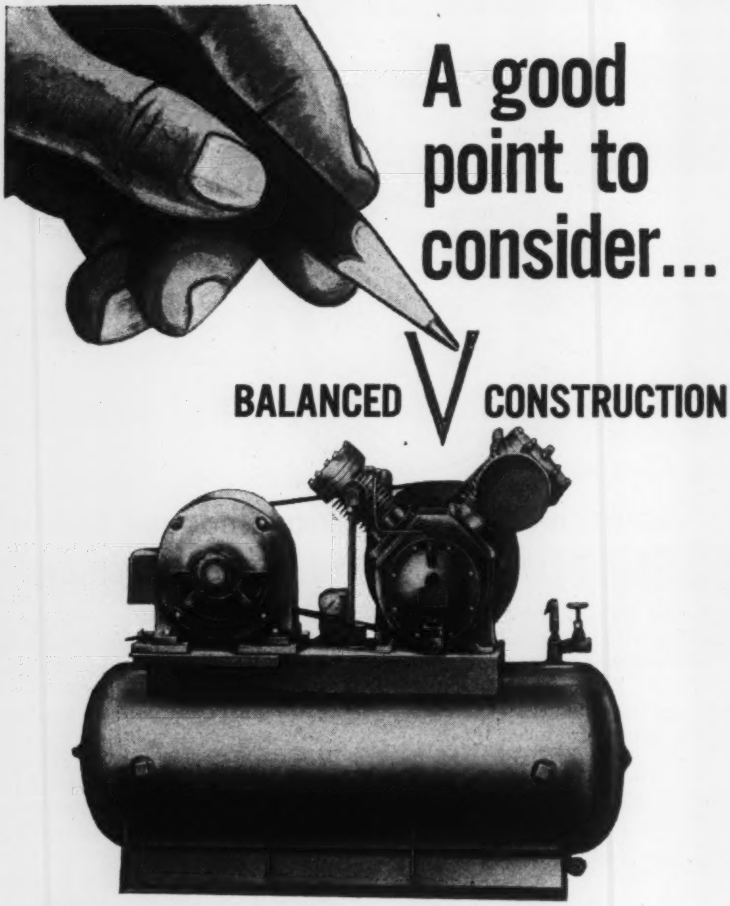

Why the I-R Air Compressor is right for your product!

WHETHER YOU ARE DESIGNING equipment for your own operation or for resale, there are many points about Ingersoll-Rand's *Balanced V Construction* which will help maintain the quality of your air-powered product. These 3 advantages are typical:

1. **Dependable performance.** The I-R compressor is built to operate reliably, quietly, years longer.
2. **Efficient design.** It delivers more air-per-horse-power, size for size, than other compressors.
3. **Looks like Quality** . . . and it is! Compact, well-constructed, durably built, it carries the name and has the quality plant operators expect.

Get more detailed information on I-R Air Compressors—½ to 20 H.P.—to determine the advantages they bring to your own products. For prompt response, write to:

Ingersoll-Rand
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Circle 644 on page 19

mits two simultaneous welds in one operation. Guns are easily interchangeable by means of a disconnecting cable. Retracting arm carries the weight of the cable and permits operation over an area with a radius of 8 ft. The welder operates with a 115 or 230 v ac, single phase, 50-60 cycle power supply. Portable cart is of structural steel construction and has two 12-in. diam wheels. *Joyal Products Inc., Newark, N. J.*

**Punching Machine:** Redesigned Model 10-AA fabricator, a 20-ton press, punches printed circuit boards. It reproduces any pattern of holes up to 15 x 25 in. area from a master template up to ¼-in. thick. Holes of any shape from 0.030 to 3½ in. diam can be punched cold in most dielectric materials. Good hole quality is assured by close-fitting guides which accurately align punch tip with the die. Template and workpiece are located by means of precision-ground locator pins. The press reciproates at 165 strokes per minute. Punch changes are made in 15 seconds in sizes up to 1¼ in. diam. *Wales-Strippit Corp., North Tonawanda, N. Y.*

**Marking Machine:** Model 20A cylindrical object marking machine imprints designations on vacuum tubes ranging from miniature glass types to pear-shaped types by means of five different interchangeable chutes. Chutes are marked according to tube types they will accept, together with calibrated scales. Chute feed and automatic ejection provide production speeds from 3000 to 7000 tubes per hr. Precision molded rubber printing elements and marking compounds for glass and metal assure clear imprints. Maximum imprint size is 2⅞ x 6 in. Unit is powered by a ¼-hp motor drive. *Markem Machine Co., Keene, N. H.*

**Injection Molding Machine:** Model 616-PP-12 plastics injection molding machine molds low-pressure, linear-type polyethylenes as well as other types of plastics. Pre-plasticizer design permits the use of low injection pressures. The pre-plasticizer has a separate power source that can be positioned in a remote location. Operating

Circle 645 on page 19→

'S SMALLER.... IT'S LIGHTER

IT'S RIGHT FOR MODERN EQUIPMENT

Wagner
A.C. MOTOR

Type RK, Capacitor-start, ⅙ or ¼ hp.

# the WAGNER "48"

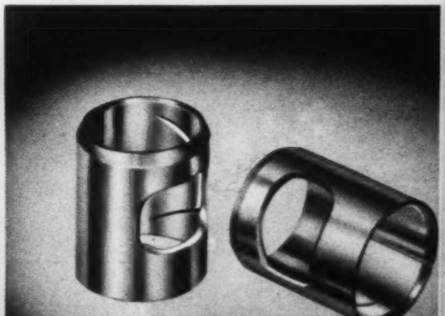
## new fractional horsepower motor

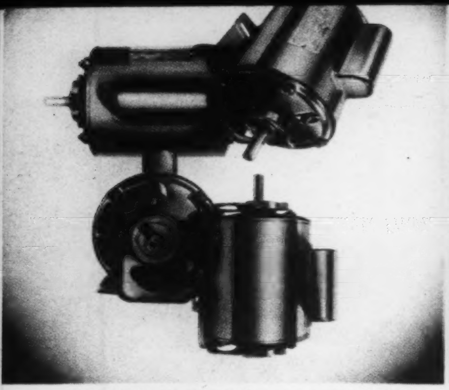
Here's the 48 frame motor you've been looking for! The Wagner "48" comes with either resilient or rigid base ... capacitor-start or split-phase type. You get the standard 48 frame size—with from *three* to *eight* pounds less weight per motor than previous models in the same hp ratings! The Wagner "48" is easier to handle ... to stock ... to install. Yet it's packed with Wagner quality—a known value for more than 65 years.

**MYLAR*-PAPER LAMINATED SLOT INSULATION** combines top moisture resistance with high dielectric strength and thermal stability—gives the Wagner "48" more application versatility, longer life, when unexpected overloads occur. *DuPont trade mark.

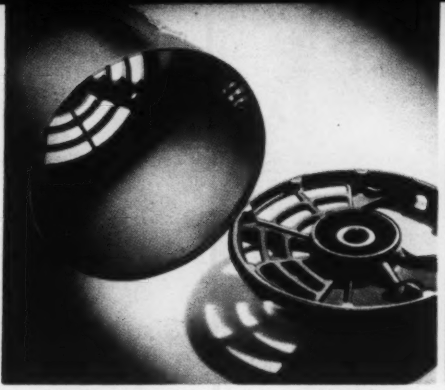
**QUICK BREAK SWITCH,** that disconnects the starting winding and capacitor from the line at a predetermined speed, makes and breaks with minimum arcing —is dependable and trouble-free.

**BABBITT LINED BEARINGS** give *smooth* performance. They stand heavy pressures with low temperature rise, have superior anti-seizure and non-scoring characteristics, are corrosion-resistant.

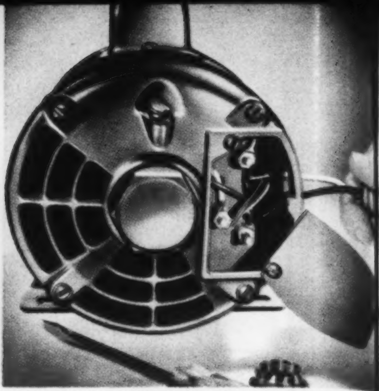




**ALL ANGLE OPERATION.** You can mount the Wagner "48" at any angle. A new lubrication system assures positive protective lubrication in any position.



**LIGHT WEIGHT STEEL FRAME,** precision-machined for accurate endplate fit, combined with CAST ALUMINUM ENDPLATES, gives the "48" strength with light weight.



**EASY TO CONNECT.** Just loosen one screw for access to terminal board. **EASY TO SERVICE** . . . no need to disconnect leads when removing endplates.

## solves problems for the design engineer

For design engineers who've been looking for light weight, fractional horsepower motors with less bulk—here's good news!

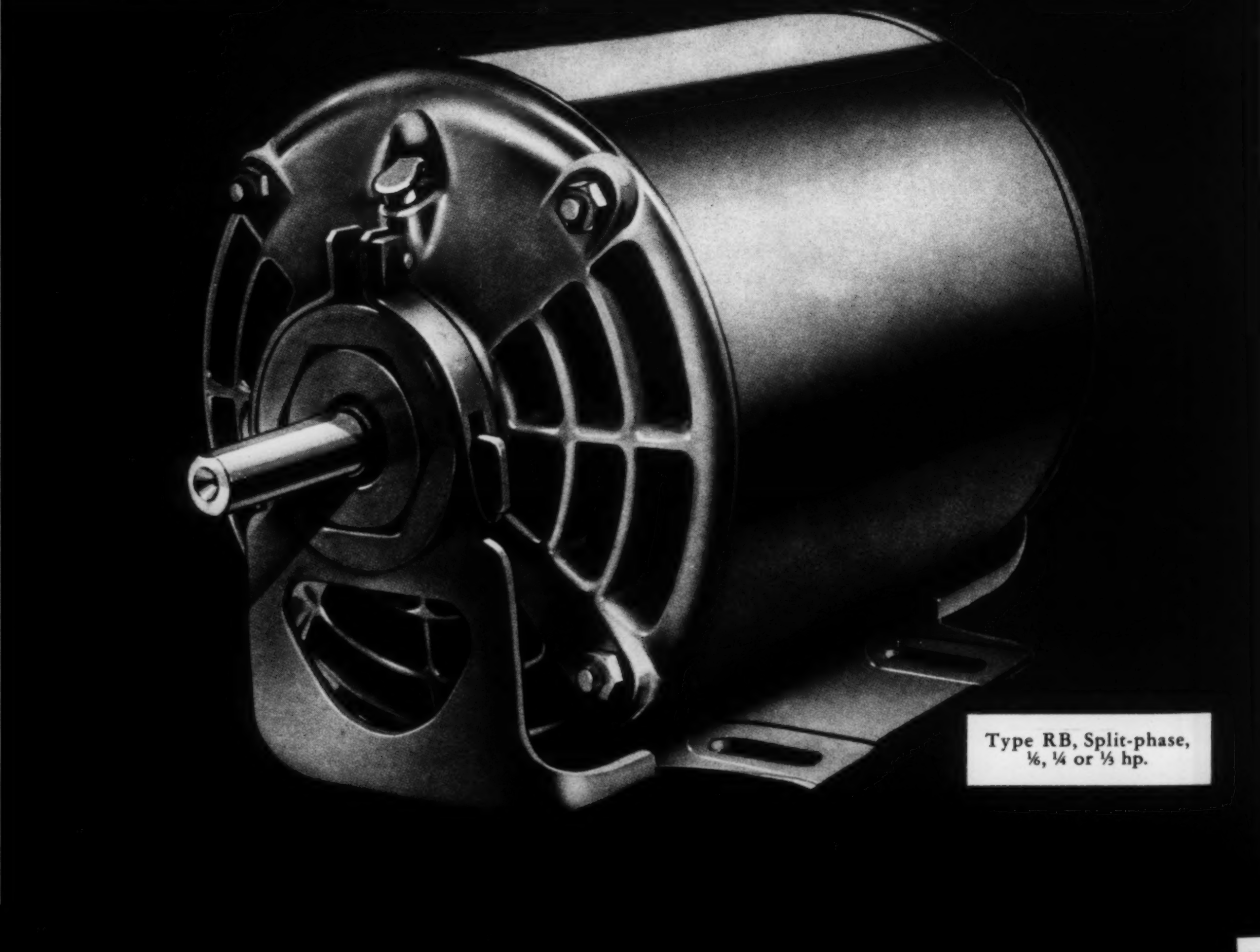
Wagner "48" capacitor-start or split-phase motors are rugged enough to permit direct mounting, are compact enough to fit in tight spots, are exceptionally light in weight, and operate efficiently when mounted at any angle. Both types are available with resilient bases or with rigid bases that are *welded* to the steel motor frames to provide great strength. Through ventilation assures cool running motors that last longer.

If you would like to test the new Wagner "48," one of our field engineers will be glad to furnish a sample motor. Contact the Wagner Branch near you or write us.

**WAGNER ELECTRIC CORPORATION . . . 6400 Plymouth Avenue, St. Louis 14, Missouri**

M56-1

# the WAGNER "48"



Type RB, Split-phase,
⅙, ¼ or ⅓ hp.

cycle of the machine can be interrupted indefinitely without burning or changing viscosity of material in the heating chamber. The unit dry cycles 360 times per hour, shoots 22 oz of polystyrene (36 cu in.), plasticizes 145 lb of material per hr and exerts 25,000 psi injection pressures. Clamp mechanism provides hydraulic mold-clamping pressures to 200 tons. *Lewis Welding & Engineering Corp., Cleveland.*

### Testing and Inspection

**Cam Comparator:** New 3 D comparator gives readings on both two and three-dimensional cams accurate to ±0.0002-in. Measurements of ±0.0001-in. are possible on highest precision work. The unit gives true readings on an infinite number of specified points and also measures an infinite number of points between stations, compared with a master. The comparator checks 50 to 60 cams per day. It employs a ball probe, exactly the size used for a follower, to trace the contours of the work. Counterbalance maintains constant micrometer pressure on the probe. Master and duplicate cams revolve on a single arbor, and any discrepancy of dimensions is indicated on an air gage. *Parker Stamp Works Inc., Hartford, Conn.*

**Contour and Surface Projector:** Magnavisa contour and surface projector is designed for the inspection and examination of relatively flat objects and small parts, imprinted circuits and fine print of small-scale drawings. Two models are available—one enlarges the material three times and the other five times. The unit can be used for prolonged periods without eye strain in any normally-lighted area. Materials to be examined are placed on a two-way movable platform. Counterbalanced optical head is lowered into contact and the magnified image is projected onto a uniformly illuminated 4½ x 12-in. viewing screen. Additional areas of the object can be examined by moving the platform in the desired direction. Unit weighs 18 lb, is 21⅛ x 13¼ x 13¼ in. in size. *American Optical Co., Instrument Div., Buffalo.*

THE

simplest answer

TO BEARING PROBLEMS

Bunting capability and leadership in the field of Cast Bronze Bearings and parts are well established and widely recognized. Today Bunting offers an equally comprehensive and responsible service in the field of Sintered Powdered Metal Bearings and parts.

Bunting's special knowledge and facilities make Sintered Powdered Metal products available in many applications not heretofore considered feasible. We can help you find the simplest answer to your individual problem, be it Cast Bronze or Sintered Metal.

A wide range of stock sizes of Bunting Cast Bronze and Sintered Powdered Bronze self-lubricating, plain and flange bearings, thrust bearings and bars are available from Bunting distributors everywhere in America.

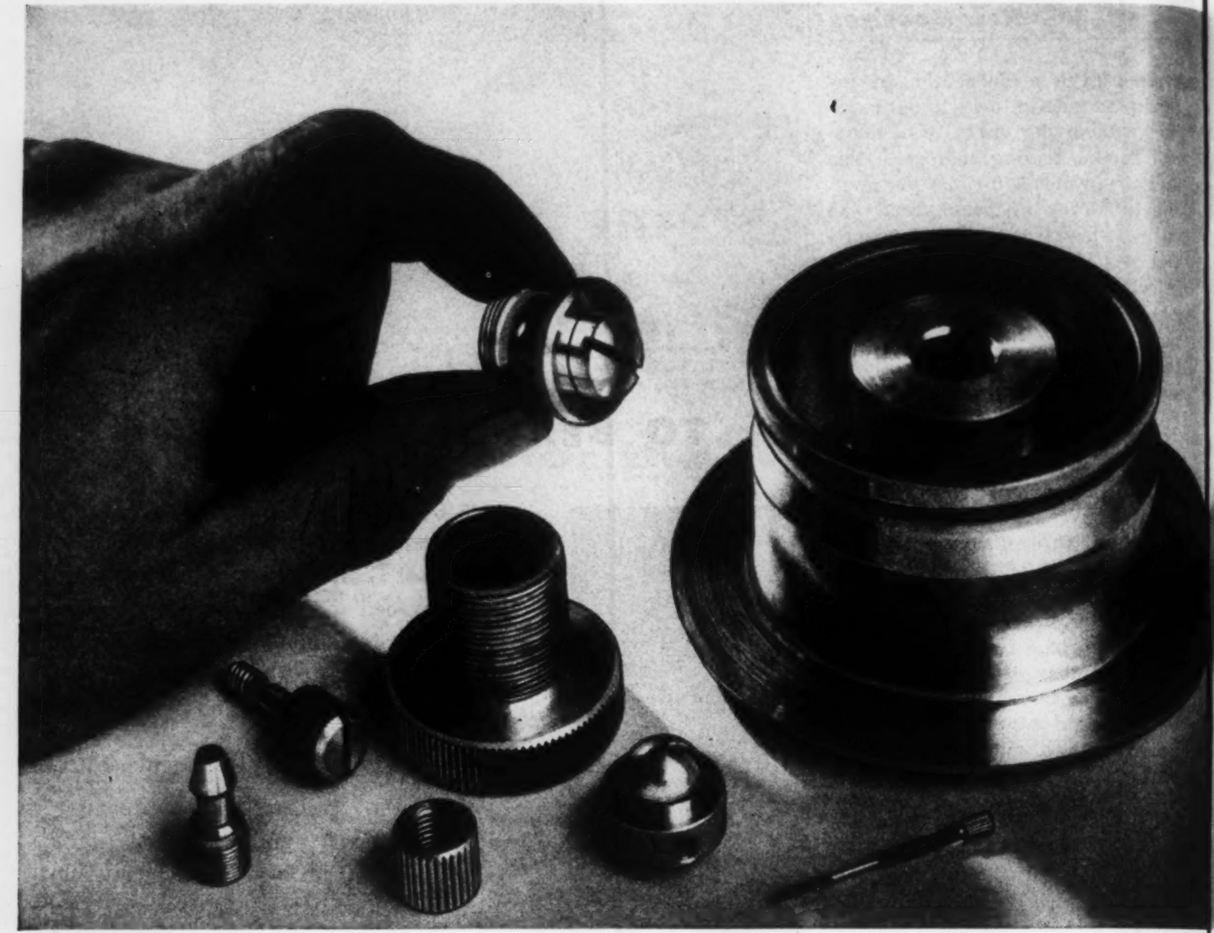
*Write for catalogs.*

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS
OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

Circle 646 on page 19



Typical parts machined by Taylor Instrument Companies from Alcoa Aluminum Screw Machine Stock

HOW TAYLOR INSTRUMENTS* GET A LIFT AND A LONG LIFE FROM ALCOA SCREW MACHINE STOCK

Where measurements must be precise, you'll find Taylor Instruments . . . insuring a jet pilot's safe descent by parachute . . . warning a ship's captain of changing weather . . . telling the doctor your temperature and blood pressure. In everyday life, and in thousands of industrial plants, Taylor Instruments have helped America measure its progress since 1851.

What are Taylor's requirements for screw machine parts? Precision, naturally. Corrosion resistance is also important since many Taylor Instruments are installed where maintenance is virtually impossible. Because many Taylor products, like your home thermometer, are mass-produced, cost is exceptionally important in the selection of a screw machine stock.

With these requirements in mind, read why Taylor Instrument Companies use Alcoa® Aluminum Screw Machine Stock. See if their experience plus the inescapable economics of aluminum versus brass doesn't dictate a hard look at all your screw machine parts. For competent technical help in making such an analysis, simply call your local Alcoa sales office listed under "Aluminum" in your classified phone book. Aluminum Company of America, 873-M Alcoa Building, Pittsburgh 19, Pennsylvania.

*Taylor
INSTRUMENT COMPANIES

## IN PURCHASING

Asst. Purchasing Agent, J. R. Mahan, says, "Dependability is the single most important requirement of a supplier. This we get in full measure from Alcoa. Quality has always been dependable. Deliveries have come when promised. Service and technical help are always available to us and their answers are right. We find this Alcoa dependability also applies to Alcoa distributors from whom we get prompt delivery."

## IN METHODS ENGINEERING

H. D. Klitgord, Manager, Methods Engineering Department, says, "We have a continuous cost study of materials for all of our screw machine parts. Equal or better performance has been our criterion in every instance where money could be saved. We are saving $100,000 per year by using aluminum. Our conversion at present is about 40% and we anticipate an increasingly greater use of aluminum bar stock."

## IN PRODUCTION

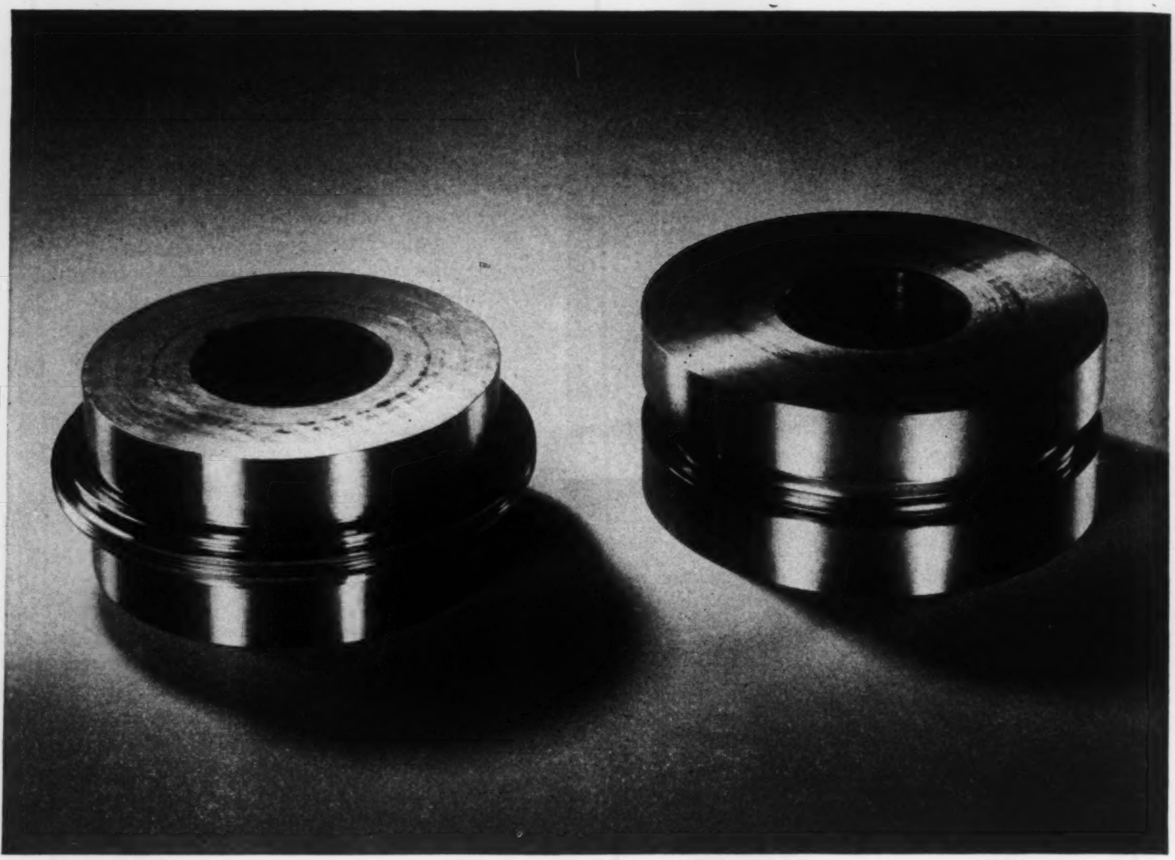
Mr. H. Bubel, Group Leader, Automatic Screw Machine Department, says, "We are machining aluminum at the maximum production rates possible. Alcoa technical people have been of great assistance to us in recommending cutting oils and tools, and helping us maintain our close tolerances and fine finishes."

**THE ALCOA HOUR**
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

*Your Guide to the Best in Aluminum Value*

ALCOA
ALUMINUM
SCREW MACHINE STOCK
ALUMINUM COMPANY OF AMERICA

*Circle 647 on page 19*



# how Vacuum Metals FERROVAC solved critical surface problem for Bausch & Lomb . . .

The jewelers' rolls Bausch & Lomb use to roll gold-alloy wire for eyeglass frames must be *mirror-smooth.* Rolls of conventional air-melted alloys just didn't work out economically. A normal amount of nonmetallic inclusions in the metal meant they had to be ground and reground, polished and repolished, before the surface was satisfactory. And even then, many rolls had to be scrapped when finishing uncovered inclusion pits.

The solution to this problem proved to be Vacuum Metals FERROVAC® Airdi 150. A better finish was obtained without any regrinding—and the number of scrapped rolls fell to zero. Here's why: Vacuum-melting removes the gases which create nonmetallic inclusions in the molten metal before they get into the product. This means cleaner metal, smoother surfaces. What's more, vacuum-melting improves fatigue, creep and impact strengths . . . reduces brittleness.

Vacuum-melted metals are the answer to jobs where surface is critical—like gauge blocks, plug and ring gauges, rolls for aluminum foil—as well as many other specially demanding applications. They're available in most grades and sizes, including special ferrous and non-ferrous alloys. Write now for a free analysis sheet on which to describe your application. It will help us both decide how vacuum-melted metals can serve you best. *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, New York.*

VMC

**VACUUM METALS CORPORATION**

**Division of Crucible Steel Company of America**

*Circle 648 on page 19*

# GE VALUE ANALYSTS SAVE 80%

## COMBINE SMALL GRC ZINC DIE CAST AND MOLDED NYLON MATING PARTS

### Informative Die Casting Bulletin Gives Examples, Facts from Gries

Gries' fact-filled die casting bulletin shows many examples of how GRC may help you solve your small parts problems. It also tells about GRC's design engineering services for the solution of specific problems. Send for this bulletin today or, send prints for prompt quotations on quantities of 100,000 to many millions — completely trimmed, ready to use, precision made die cast parts. Smallness of Gries die castings is unlimited; maximum weight 1/2 oz., maximum length 1¾ in.

GRC
SMALL
EXCLUSIVELY

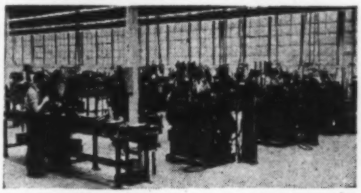
### Gries' Tiny Molded Plastic Parts Offer Wide Design Latitude

The infinite possibilities offered by Gries' methods in molding tiny plastic parts offer design engineers almost unlimited latitude in their designs.

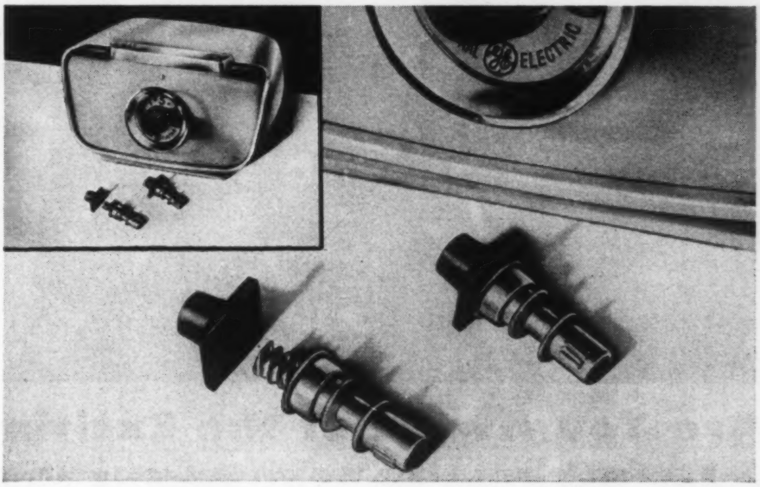
GRC molds all thermoplastics—Nylon, Kel-F, acetates, polystyrene, polyethylene, etc., with Nylon a specialty. Maximum length 1¼"; maximum weight .03 oz; minimum unlimited.

A new bulletin is now available giving complete details of Gries Plastics Molding Division. Send for it today.

### Gries Reproducer Offers Complete Production Facilities



Included in the many facilities offered at the modern Gries plant are complete departments for performing secondary operations such as tapping, drilling, assembling, reaming, and special machining. Practically all commercial finishes can be applied in GRC's specialized plating department.



**Gries molded nylon nut and zinc alloy die casting form mating units for GE electric blanket control part, at one-fifth the cost of the original expensive screw machine parts.**

### *GENERAL ELECTRIC UTILIZES GRIES' INGENUITY: BUYS PARTS FOR ELECTRIC BLANKET CONTROL AT 1/5TH OF FORMER COST; GRIES TECHNIQUES ALSO IMPROVE PRODUCT'S BASIC DESIGN*

**Value Analysts at GE's Automatic Blanket Division consulted Gries Reproducer Corp. in an effort to lower cost and improve design of their manufactured products. One result: over 80% savings on the two intricate parts illustrated above now produced as zinc alloy die cast and molded Nylon mating parts.**

Gries exclusive techniques made it possible to die cast the threaded shaft—a former screw machine part—with threads, holes and metal-saving indentations as integral parts of the casting, delivered ready-for-use.

The GRC Nylon part, formerly a special screw-machine brass nut, is now molded in one integral piece with accurate, *molded,* internal threads.

The combination not only results in superior part performance but the overall savings on these two components is over 80%.

This is only one example of the many types of savings that Gries' unique methods are affording industries in the production of better and more economical small parts.

These examples illustrate how well GRC, as a single source of supply, can precisely "mate" parts, even of different materials.

GRC again demonstrates its ability to supply industry with tiny parts at lower cost—with additional built-in economies and superior performance.

WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS

**GRIES**

**GRIES REPRODUCER CORP.**

32 Second St., New Rochelle, N. Y. • New Rochelle 3-8600

design instructions
Make it smaller, lighter
design instructions
Automatic operation is important
design instructions
Improve operating efficiency

# Are You Aware of the Exciting Opportunities for Product Improvement that Exist Now?

Today, industry is forging ahead in the development of products little dreamed of only a few short years ago.

Instrumentation . . . miniaturization . . . more automatic production . . . all are demanding parts and components with new operating advantages. And High Nickel Alloys are playing an important part in meeting the needs. Are *you* aware of the opportunities High Nickel Alloys offer? For example, do you know you can . . .

**. . . Design smaller, lighter weight units through the use of "extremely sensitive" alloys that respond to very weak electrical currents?**

**. . . Assure precision product performance with the help of an alloy that exhibits infinitesimal size change through temperature ranges up to 400°F?**

**. . . Compensate a given magnetic field for temperature changes to insure consistently accurate product performance?**

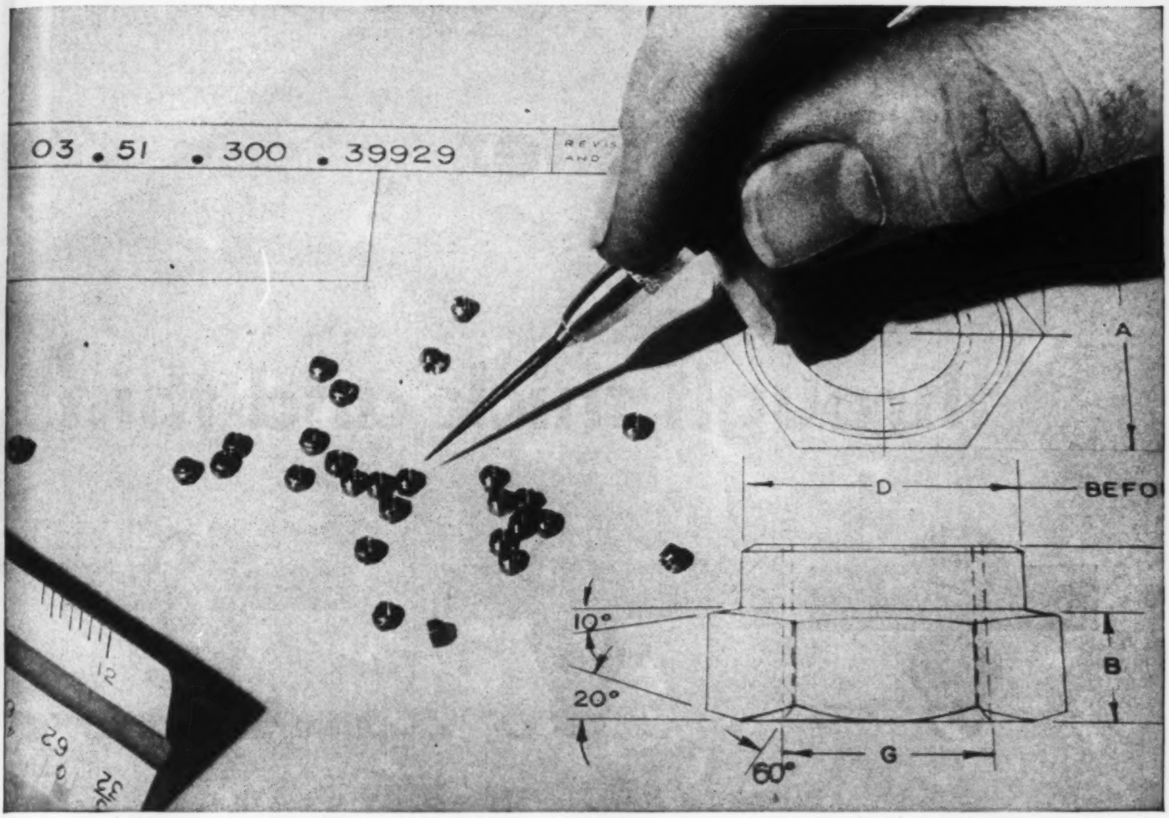
And the list goes on . . . an exciting list of properties that can lead to rewarding fields of new and improved products!

Getting High Nickel Alloys to do special jobs for you . . . making them behave in the way *you want them to behave* . . . is an opportunity we welcome. By making a team of your engineering experience and Carpenter's ability to produce closely controlled High Nickel Alloys with predetermined behavior, you often take an immediate step to product improvement. To help you in this job, Carpenter manufactures an unusually complete line of High Nickel Alloys . . . Temperature Compensator, Low Expansion, High Permeability and Glass Sealing Alloys. These are available in the largest variety of forms including strip, wire, bars, tubing, forging billets, etc. Ask for detailed engineering and application information. A note on your company letterhead is all that's necessary.

**Carpenter STEEL** **High Nickel Alloys**

Pioneering in Improved Tool, Alloy and Stainless Steel Through Continuing Research
THE CARPENTER STEEL CO., 120 W. Bern St., Reading, Pa.
Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

*Circle 650 on page 19*



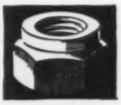
**FLEXLOC MICROSIZE** locknuts meet designers' needs for tiny precision nuts that retain strength and holding power in the smallest assemblies—servomechanisms, electronic and electrical equipment, all miniature devices.

# New FLEXLOC Microsize Locknuts

## Now available in Alloy Steel, Stainless Steel, Brass and Aluminum for lighter, more compact designs

| SIZE | Across Flats | | Shoulder Height | | Across Corners | Height +.000 −.003 |
|---|---|---|---|---|---|---|
| | MAX. | MIN. | MAX. | MIN. | MIN. | |
| 0-80 NF-3B | .111 | .107 | .047 | .042 | .123 | .075 |
| 1-64 NC-3B | .127 | .123 | .0635 | .0585 | .141 | .090 |
| 1-72 NF-3B | .127 | .123 | .0635 | .0585 | .141 | .090 |
| 2-56 NC-3B | .158 | .153 | .068 | .063 | .176 | .105 |
| 2-64 NF-3B | .158 | .153 | .068 | .063 | .176 | .105 |
| 3-48 NC-3B | .190 | .183 | .071 | .066 | .210 | .120 |
| 3-56 NF-3B | .190 | .183 | .071 | .066 | .210 | .120 |
| 4-40 NC-3B | .190 | .183 | .072 | .067 | .210 | .120 |
| 4-48 NF-3B | .190 | .183 | .072 | .067 | .210 | .120 |

**SPECIFICATIONS:** Available in brass (plain or cadmium plated) and aluminum (plain or chemically treated), for temperatures to 250°F; alloy steel, 18-8 stainless, for temperatures to 550°F.



New FLEXLOC Microsize locknuts are smaller and lighter than regular FLEXLOCS of the same nominal diameter. Wrenches of smaller size are used to install them. Mating joints or flanges can be designed smaller—with no loss in strength or convenience of assembly.

Microsize FLEXLOCS have all the advantages of larger FLEXLOCS. One-piece, all-metal construction—nothing to put together, come apart, lose or forget. Use them as lock or stop nuts—they stay put anywhere on a threaded member as soon as the locking threads are fully engaged. Uniform locking torques insure accurate preloading. There are no nonmetallic inserts to pop out or deteriorate. Moisture, dryness, oil won't affect these Microsize FLEXLOCS. Just screw them on. They lock and stay locked. Vibration won't shake them loose.

For complete information on Microsize FLEXLOCS, consult your authorized SPS distributor. Or write STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

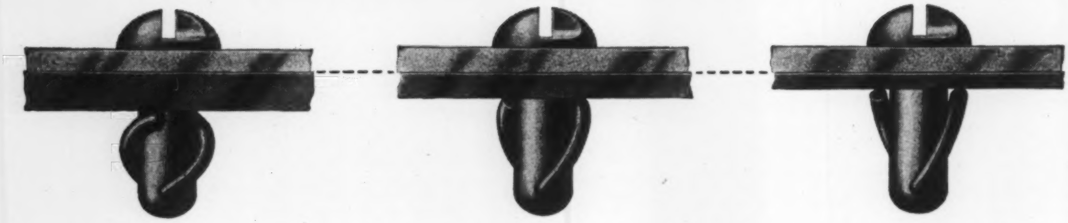
**STANDARD PRESSED STEEL CO.**

**FLEXLOC® LOCKNUT DIVISION**

**SPS**

**JENKINTOWN PENNSYLVANIA**

# This fastener works through thick and thin!



Spring-Lock—the easy-to-use removable fastener for modern designs—works whether panel thicknesses run over or under specifications! Spring wire deflects automatically to handle greater or lesser thicknesses. Spring-Lock's design flexibility makes it more than a fastener: it can be adapted as a shelf support, door strike, knob or any similar panel-mounted device. Many standard shapes and sizes of Simmons Spring-Locks are available from stock.

SIMMONS FASTENER CORPORATION

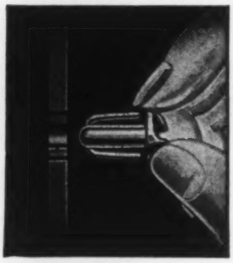
1756 North Broadway, Albany 1, New York

Simmons

QUICK-LOCK
SPRING-LOCK
ROTO-LOCK
LINK-LOCK
DUAL-LOCK

JUST OUT!
NEW 36-PAGE CATALOG WITH APPLICATIONS
SEND FOR IT!

## HERE'S HOW SPRING-LOCK WORKS



**1.** *Insert fastener.*

**2.** *Half-turn locks it in place.*

With production costs on the uptrend, you can figure on Spring-Lock as an assembly time and money-saver, because:

- **Installation is BLIND**
- **Installation is EASY: no special tools are needed**
- **Installation is QUICK: a half-turn locks it in place**
- **Installation is SECURE: the *spring* steel *locks* the fastener, resists vibration**

Send for details and samples, or write us about *your* fastening problem.

*Circle 652 on page 19*

*to engineers who are quite particular about their jobs...*

**YOU TELL US...**

WHAT DO YOU REQUIRE IN A JOB?

For years we have been offering various types of positions to engineers through the pages of this magazine.

But perhaps there is a better way. Perhaps you should tell us what you want in a job.

Tell us what you seek: type of work, salary, level of responsibility, working conditions, everything important to you.

Then let us try and find that position for you from among the hundreds now open in our company. With openings in virtually every field of engineering, on virtually all levels, we believe we can match many of your job descriptions with the actual position.

Naturally, we can't place an engineer with one year's experience in the position of a 10 year man. But in many cases, we'll be able to offer interesting promotion. We'll be able to offer you refreshing changes in type of work – and through our training programs, enable you to make the change you desire. In brief, we think we can give satisfaction to a majority of reasonable inquiries.

The brief résumé form below is for your convenience in responding. Please feel free to amplify on it.

*California Division*

**LOCKHEED**

AIRCRAFT CORPORATION • BURBANK

**CALIFORNIA**

*Circle 653 on page 19*

E. W. DES LAURIERS, DEPT. 9054
LOCKHEED AIRCRAFT CORPORATION
BURBANK, CALIFORNIA

*Here is the position I seek:*

Field of engineering (please be as specific as possible)

Salary

Educational opportunities (on-the-job training, university courses leading to advanced degrees, company training in specialized subjects, whatever programs you need for advancement of your career)

Name

Home address

City and State Age

Home phone

*(Advertisement)*

# When selecting a timer—design for availability

## Specifying one of the many standard units offered saves you and your customers time, money

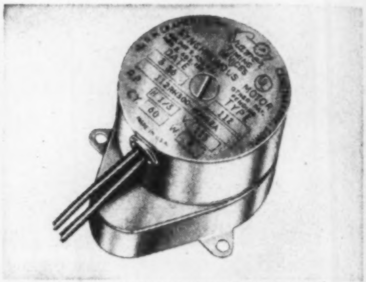
Several distinct advantages accrue when you design for a standard timer—as against making a special timer for your specific job:

Cost is lower because no engineering or tooling charges are encountered. Service is quicker and easier. Replacement is simplified. Complete descriptive information and operating instructions are in print.

**STOCK TIMERS FOR QUICK DELIVERY.** But probably the most important single reason for sticking to standards is ready availability. Quantities of the exact type, range and rating can usually be obtained immediately from manufacturer's stock for prototype or test purposes. Production quantities can be supplied with minimum lead time because design has been completed, parts inventories established and assembly techniques perfected.

**EXTREME VARIETY AVAILABLE.** Leading timer manufacturers offer extremely wide lines of standard interval timers, time delay relays, cycling timers and time totalizers. In addition, a wide selection is offered within these groups. You can, for instance, pick a standard interval, cycling or delay timer to optimize almost any characteristic needed for your design; cost, mounting, accuracy, actuating means, and degree of adjustability. Each of these sub-categories in turn provides various time ranges, control arrangements and voltage-frequency combinations.

**MINOR CHANGES EASY.** In the event you can not find a stock or catalogued timer to meet your exact needs, discuss your problem with a full-line timer manufacturer. He will frequently be able to modify a similar unit to your specifications with only minor changes, thus saving you the costs of engineering and lengthy testing.



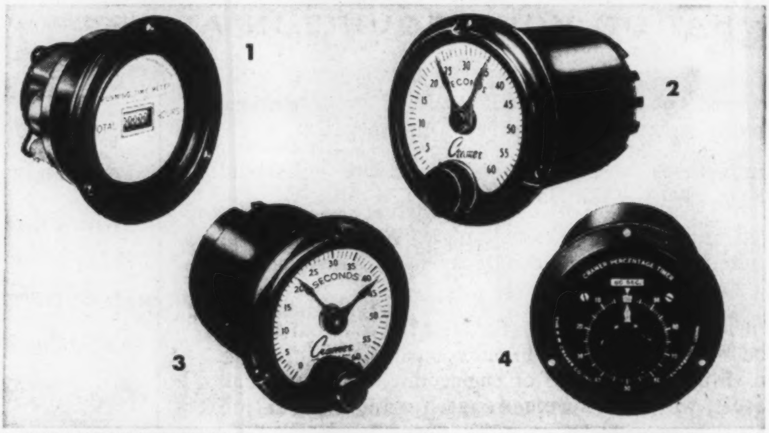
**CRAMER PERMANENT-MAGNET MOTOR**—heart of Cramer a-c timers. Available separately. Features fast start, truly synchronous operation, no coasting. *STOCKED* in many speeds, right or left rotation. Various output shafts. Torque: 30 in-oz at 1 rpm. Bulletin PB-110A.

Only rarely will you have to specify a completely new design. And then your best approach is to talk it over with the specialists in the field of time control.

**WRITE TIMER SPECS EARLY.** Timer requirements should be determined early in the design process, so that an available standard timer, with the right characteristics and proved performance, can be accommodated.

**LET US HELP YOU.** Cramer engineers are always ready to discuss your time control problems. They can tell you about interval timers, time delay relays, cycling timers and time totalizers in 85 stock variations in the wide Cramer line. And they can handle your special needs, too. Write us or see your local Cramer representative. The Cramer Controls Corporation, Box 6, Centerbrook, Conn.

**A FEW STOCK TIMERS FROM THE BROAD CRAMER LINE**



**1. TYPE 631E TIME TOTALIZER.** Registers elapsed time on 5-digit drum-type counter. *STOCKED* in total ranges of 9999.9 and 99999 hours at 115V, 60 cps. Also 9999.9 hours at 220V, 60 cps. Other available (including resettable) types count 1/10 seconds, seconds, 1/100 and 1/10 minutes, minutes, 1/10 hours and hours. Bulletin PB-610.

**2. NEW TYPE 412 TIME DELAY RELAY.** Introduces timed delay between operation of control circuit and load circuit. *STOCKED* in full-scale ranges of 6, 15, 30, 60, 120 seconds; 5, 15, 30, 60 minutes; 5, 12, 24 hours at 115V, 60 cps. Also 15, 60 seconds; 5, 15, 60 minutes at 220V, 60 cps. Bulletin PB-311.

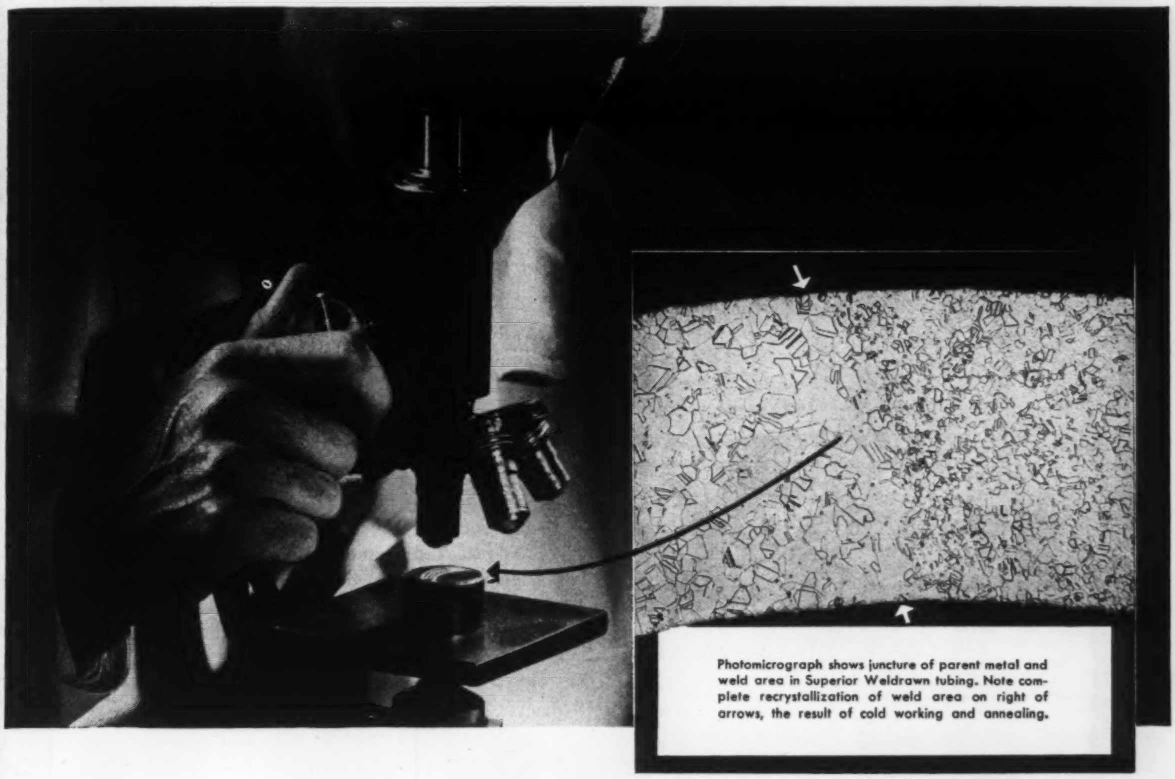
**3. NEW TYPE 241 AUTOMATIC RESET INTERVAL TIMER.** Provides pushbutton start, automatic and immediate reset for electrically operated equipment. *STOCKED* in full-scale ranges of 6, 15, 30, 60, 120 seconds; 5, 15, 30, 60 minutes; 5, 12, 24 hours at 115V, 60 cps. Also 60 seconds; 5, 15, 60 minutes at 220V, 60 cps. Bulletin PB-241.

**4. TYPE 610 PERCENTAGE TIMER.** Makes (or breaks) electrical circuit for adjustable percentage of a fixed time period. Calibrated in steps of 1% from 4 through 96. 100% setting provided. Snap action switch. *STOCKED* in ranges of 15, 30, 60 seconds; 5 minutes at 115V, 60 cps. 15, 30, 60 seconds at 220V, 60 cps. Bulletin PB-510A.

***TALK IT OVER WITH CRAMER***

CRAMER CONTROLS
CORPORATION
(Formerly R. W. Cramer Co.)

# Weldrawn® Tubing by Superior



Photomicrograph shows juncture of parent metal and weld area in Superior Weldrawn tubing. Note complete recrystallization of weld area on right of arrows, the result of cold working and annealing.

## So perfect the bead actually vanishes!

### *Here's how to cut tubing costs up to 50%*

Specify Superior Weldrawn. You get quality approaching that of seamless, at savings as high as 50%! Unlike other welded tubing, Weldrawn is offered in *any* of the intermediate sizes—made possible because of the redrawing after welding.

**"Weldrawn" Means—**

This is a tubing far superior to ordinary welded tubing for many applications requiring forming, machining and corrosion resistance. After welding, it undergoes alternate cold drawing and annealing.

The weld area recrystallizes (see photo above), acquiring mechanical properties equivalent to those of the parent metal. The bead actually vanishes!

**Costs Are Low**

Weldrawn tubing is produced in 18 different analyses, in a wide variety of sizes. Cost savings are 10 to 20%. In certain materials you save up to 50%!

**Quality Is High**

In Weldrawn you get tubing with highly uniform mechanical properties throughout, and clean, smooth, bright ID and OD surfaces. Because no filler or flux is used during welding, the corrosion resistance of the weld area is equal to that of the parent metal. And by repeated redrawing and annealing after welding, any possible faults or defects in the weld are eliminated.

**Specify Superior**

In addition to Weldrawn tubing, we also offer a wide variety of analyses and sizes in Seamless grade. So for the finest in small tubing, always specify Superior.

Whatever your problems in small tubing, Superior can help you. For additional information on Weldrawn, write for Data Memorandum No. 2. Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

*Superior Tube*

**The big name in small tubing**

**NORRISTOWN, PA.**

*All analyses available in .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD*

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

Circle 655 on page 19

## *Craftsmanship of the 20th Century*

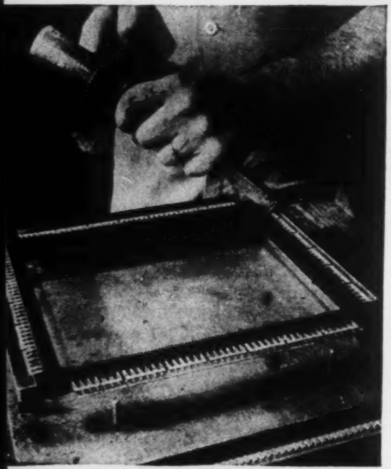
MONSANTO

Today's industrial designers work closely with plastics engineers in solving many complex design and production problems. Here is a graphic example of contributions being made by custom-molding craftsmen.

# Resinox® thermosetting plastic helps IBM electronic "brains" perform amazing feats of "memory"

**DESIGN OBJECTIVE** IBM's blue-prints for its new 704 and 705 Electronic Data Processing Machines called for special frame assemblies to house thousands of tiny magnetic "memory" cores, strung on grids of coordinate wires, which attach to terminal inserts in the sides of the frames.

**MATERIAL SPECIFICATIONS** In setting up specifications for the frame material, IBM design engineers had to consider many factors. For one thing, since the memory frames were to be stacked 35 and 36 high, no frame could deviate in flatness beyond .030 inches in the 10 inch frame length. Shrinkage also must be predictable within fine limits. Rigidity was another requirement. Although light in weight, the frame was expected to withstand up to a pound's pull from each of the wires—and there are 68 grooves for wires on the short side, 86 along the length! Next, production called for the 308 terminal posts set in the edges of each frame, to be hot-dipped in a lead-tin mix at 550°F. without distortion of the plastic. And finally, of course, the frame material must possess superior dielectric strength and other electrical properties.



*oosening metal wedges from memory frame.*

**PRODUCTION ENGINEERING** Specialty Insulation Manufacturing Company, Inc., Hoosick Falls, N. Y. was awarded the job of molding the frames. SIMCO engineers, after long thorough investigation, selected Resinox 3700 as the frame material. Less expensive than other materials tested, this Monsanto thermosetting plastic was easier to handle, easier to transfer mold. Its electrical characteristics passed IBM's tests. It possessed excellent dimensional stability, stayed flat, rigid. Resinox 3700 had an extremely low predictable shrinkage. Its heat resistance permitted hot dip soldering.

The frames are being molded of Resinox 3700 in conventional 100-ton transfer-molding presses. A molding temperature of 310°F. is used. Molding time is two minutes. Loading 9 oz. of Resinox in the press is accomplished by first preforming the powder into six 1" x 2" pills, then preheating the pills to 275°F. in an electronic preheater for 10 to 15 seconds.

ELECTRONIC DATA PROCESSING MACHINE

**THE FINISHED PRODUCTS** These two new and advanced IBM Electronic Data Processing Machines, which can remember up to 40,000 letters, numbers or symbols and can recall facts in a few millionths of a second, are solving many highly complex business and scientific problems including ones connected with top defense projects. One machine, for example, is making high speed calculations in jet engine design. Another is being installed for use in nuclear weapon development. A third is involved in the design of gas turbines.

The contributions that plastics custom molding craftsmen have made in the development of this giant electronic "brain" are being repeated in hundreds of cases in all phases of industry. The skills and services of these 20th Century craftsmen are available to every manufacturer designing for greater efficiency and lower costs. As a major supplier of plastic resins, Monsanto is in a position to direct you to custom molders who can bring long experience and detailed knowledge to bear on your problems. Write to Monsanto Chemical Company, Industrial Applications Dept., Room 611, Springfield 2, Mass.

MONSANTO

RESINOX®

Investigate Monsanto's completely balanced line of phenolic plastic compounds developed for particular applications and sold under the trade name Resinox.

Circle 656 on page 19

NOSCO 'CAN DO'

# *Two at a time...*

## *Wastebaskets molded for higher production... lower cost*

A major manufacturer of metal housewares decided to broaden his line by adding plastic wastebaskets. His first step was to call in a Nosco sales-engineer . . . logical, because Nosco men are qualified plastic-parts technicians who know exactly how to put Nosco engineering and production facilities to work. The Nosco plant thus becomes the customer's own plastic molding department!

For the 8-quart basket, Nosco engineered *the deepest two-cavity mold ever built.* This hot-runner mold, which virtually eliminates all scrap, weighs more than a ton and is run in one of Nosco's large pre-plasticized presses.

The two larger size wastebaskets, pictured above, are now molded one at a time, but when production warrants, these parts can also be molded in two-cavity dies.

Nosco "Can Do" enabled this manufacturer to successfully produce deep-drawn parts at lower cost. Why not let one of our sales engineers put Nosco "Can Do" to work in designing your next plastic part? Please write.

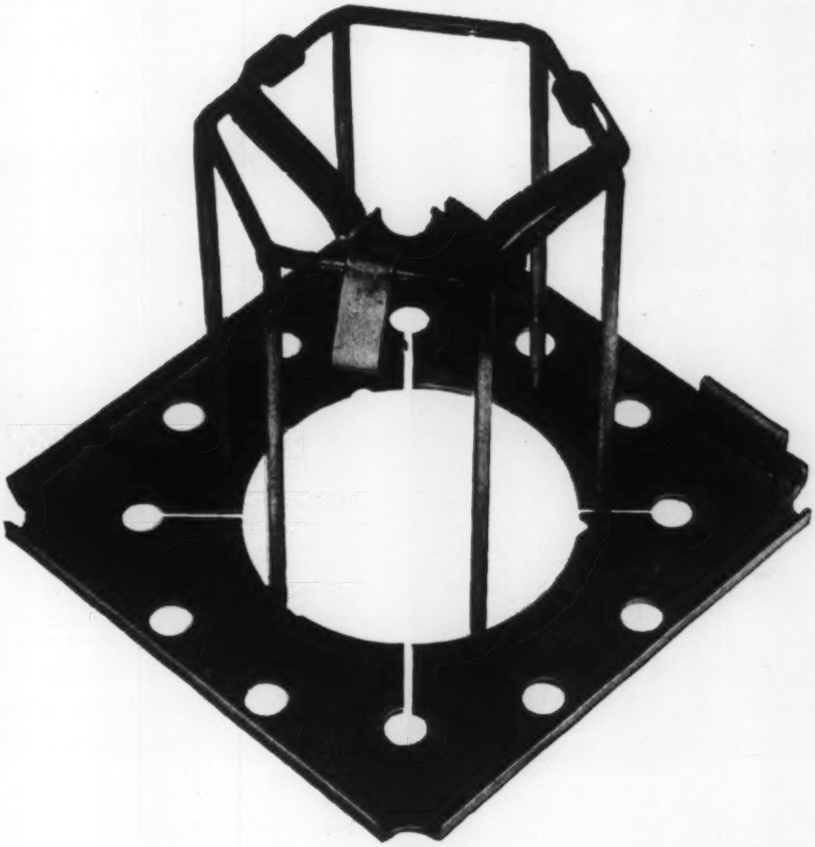
**NOSCO plastics, inc. • erie 2, pa.**

*World's largest injection molding plant*

NOSCO PLASTICS

For other case histories—and for a glimpse of the Nosco plant and facilities, send for the free 12-page brochure, "How the Nosco Plant Works to Produce Your Needs in Pratical Plastics."

Circle 657 on page 19



# Still in Use after 1½ Years

## of Heating and Quenching

This tray, made of a HAYNES high-temperature alloy, has been subjected to continual heating and cooling for 18 months . . . and it is still in good shape.

In the heat-treating operation, trays and rings are heated to 1550 deg. F for a half hour and then given a rapid oil quench. This repeated exposure to high temperatures and thermal shock caused other trays to twist out of shape in a few days.

The HAYNES alloy used to solve this problem was HASTELLOY alloy C. There are 10 other HAYNES high-temperature alloys—each designed to resist certain severe operating conditions. All of the alloys have remarkable strength at high temperatures, coupled with excellent oxidation resistance and dimensional stability. One of them may be the answer to a production or maintenance problem in your plant.

For information on prices, available forms, and properties of these alloys, write to our general sales office in Kokomo, Indiana or to any of the District Sales Offices listed below.

**HAYNES**
TRADE-MARK
**ALLOYS**

**HAYNES STELLITE COMPANY**
**A Division of Union Carbide and Carbon Corporation**
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

*"Haynes" and "Hastelloy" are registered trade-marks of Union Carbide and Carbon Corporation*

*Circle 658 on page 19*

Specify GARDEN CITY FANS!

Standard Steel Plate Exhauster

Design B Multiblade (Forward Curve)

There's a DEPENDABLE GARDEN CITY FAN for every need

Want efficient movement of air?
Send your O.E.M. specifications to
Garden City's engineers!

- **More advanced design**
  77 years experience in making fans! Designs are simple, scientific, proven.
- **Tougher, thicker steel**
  Stamina to endure thru the years! Heavy gauge steel which resists abrasion and corrosion for a longer period of time.
- **Lower maintenance costs**
  These rugged fans stand up under roughest conditions. Sturdy construction requires minimum maintenance.
- **Remarkable performance**
  High temperature fans will move hot gases up to 1650 F. Air-cooled shaft saves dollars on your bearings-upkeep.

***WRITE TODAY FOR CATALOG . . . and ask to see long list of blue chip industries using Garden City Fans***

**GARDEN CITY FAN COMPANY**
ESTABLISHED 1879

332 S. Michigan Ave.
Chicago 4, Illinois
Dept. G

Representatives in Principal Cities

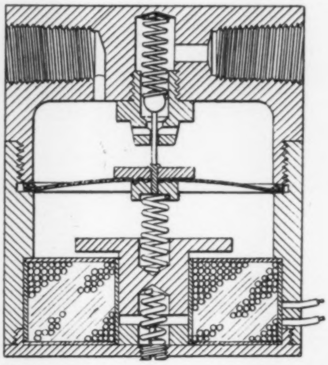
• Fans for Industry • Backward Curve • Forward Curve
• Material Handling • Radial Bladed • Small Exhaust

Circle 659 on page 19

# NOTEWORTHY Patents

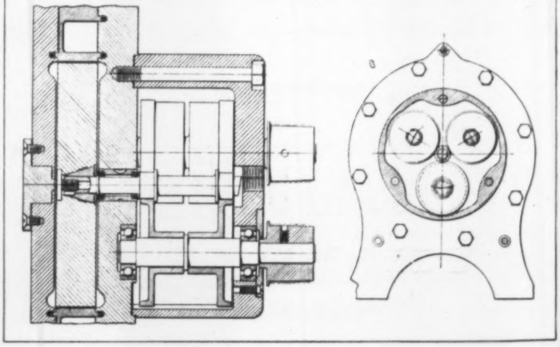
### *Dual-Range Pressure Regulator*

Regulated pressure at either of two flow rates is provided by a dual-range, electromagnetically operated pressure regulator. Combining functions of a pressure regulator and a high-low metering valve, the unit finds application in the control of gas or liquid-fuel burners, or in similar installations that require pulsation-free flow at two different volume levels. Regulator establishes minimum flow rate when solenoid is energized; maximum rate operation corresponds to the de-energized state of the solenoid. *Patent* 2,764,996 *assigned to Hupp Corp. by Richard J. Brown.*

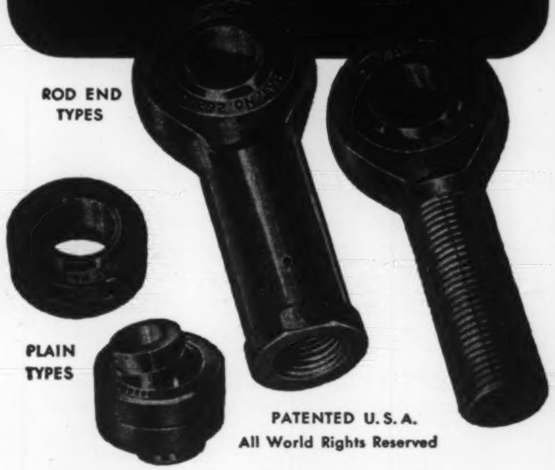


### *Ultrahigh-Speed Drive*

Output speeds ranging from 100,000 to 200,000 rpm are developed by a high-speed drive unit that operates with minimum vibration and wear. Comprising three stub-shaft-mounted input drive rollers in frictional engagement with the surface of the output shaft, the unit employs dynamic-damping devices in the roller interiors to suppress vibration at critical



# "MONOBALL" Self-Aligning Bearings



PATENTED U.S.A.
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## CHARACTERISTICS

| | ANALYSIS | RECOMMENDED USE |
|---|---|---|
| 1 | Stainless Steel Ball and Race | For types operating under high temperature (800-1200 degrees F.). |
| 2 | Chrome Moly Steel Ball and Race | For types operating under high radial ultimate loads (3000-893,000 lbs.). |
| 3 | Bronze Race and Chrome Moly Steel Ball | For types operating under normal loads with minimum friction requirements. |

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-56.

**SOUTHWEST PRODUCTS CO.**
DUARTE, CALIFORNIA

Circle 660 on page 19

---

*molded Brush Holders*

**Now Available MOLDED NYLON as well as Phenolic**

*supplied from stock*

*to help motor makers*

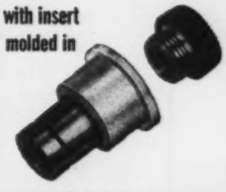
*build better motors*

### EXTERNAL THREAD?

with insert molded in

### INTERNAL THREAD?

with insert molded in



### MOLDED THREADS?

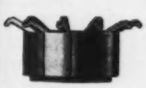
on holders and caps

### BRUSH CAPS TO FIT?

Internal or External Thread

Many Stock Sizes

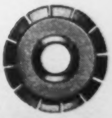
### MOLDED COMMUTATORS?



with or without prongs

or segmented

Complete Range of Stock Sizes



*Send Blueprint for Quotation*

**Midwest Molding**
AND MANUFACTURING COMPANY
GURNEE 98 ILLINOIS

Chicago Phone: Dickens 2-0777
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**PLASTICS** · TOOLING · COMPRESSION · INJECTION

Circle 661 on page 19

DOES
THIS
RUBBER PART
BELONG IN
YOUR PRODUCT?

The most important factor about any rubber part is its ability to do the job for which it is intended. Most parts are specifically engineered for the application . . . and consideration is given to elasticity, temperatures to be encountered as well as resistance to petroleum derivatives, chemicals and abrasion.

STALWART ENGINEERS have the experience and facilities to compound special rubber stocks to meet even the most unusual requirements . . . and from more than 500 different compounds already at their disposal, they can mold, extrude, die-cut, lathe-cut or mandrel-build shapes to meet any specifications.

SPECIFY STALWART RUBBER PARTS FOR THAT ONE ESSENTIAL QUALITY . . . THE ABILITY TO DO A JOB . . . BEST!

Write today for catalog 56-SR-3

STALWART
RUBBER COMPANY
180 Northfield Road • Bedford, Ohio

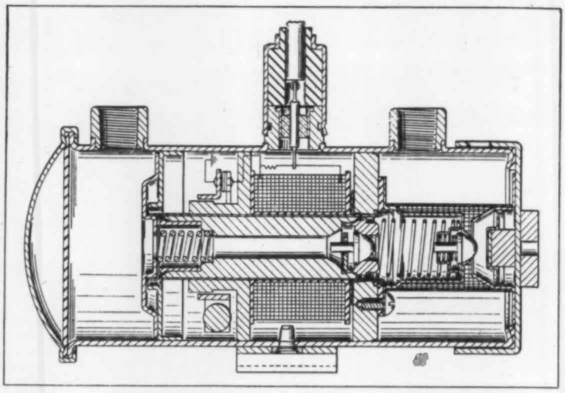
6905-SR

Circle 662 on page 19

speeds. Use is intended in high-speed instrument and machine applications. *Patent* 2,765,665 *assigned to Beckman Instruments Inc. by Edward Pickels and Philip F. Scofield.*

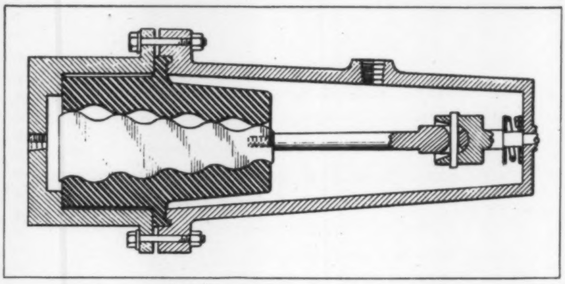
### Electromagnetic Pump

Suspensions of nonfilterable abrasive substances—for example, mud or dirt—have negligible effect on the operating life of an electromagnetically actuated, plunger-type pump. Contamination of plunger-cylinder wearing surfaces is minimized by the squeegee action of flared, wool-felt sealing rings mounted at both plunger ends. Particles not removed by this action are trapped beneath the surface of the felt without affecting its nonabrasive wiping characteristics. Transfer of liquid from inlet chamber (right) to outlet chamber (left) is accomplished by action of the electromagnet and spring which alternately reciprocate the plunger. *Patent* 2,764,098 *assigned to Bendix Aviation Corp. by John W. Dickey and William J. Randolph.*



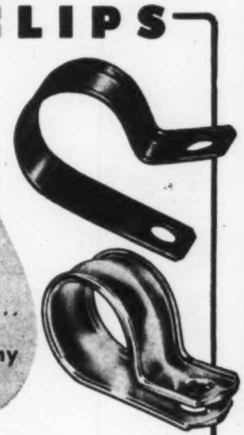
### Cone-Type Compressor

Low starting torque and reduced friction losses are characteristics of a cone-type compressor utilizing a centrally supported stator of resilient material. Circumferential outer flange on the stator divides the compressor casing into high-pressure and low-pressure chambers (right and left), permitting the high-pressure discharge to radially compress only the small end of the flexible stator. Result is to maintain high sealing efficiency between rotor and stator



# WECKESSER

## CABLE CLIPS



*of all nylon ....*

**for high heat or other severe conditions**

*of ethyl cellulose ...*

**for maximum economy in average conditions**

Light weight, strong, chemically resistant. No short circuits, no grounds, no corrosion, no rust. Only one fastener needed Sizes to 1¼ inches. Write for free samples and price sheet.

**WECKESSER COMPANY**
5715 Northwest Hwy., Chicago 30, Ill.

*Circle 663 on page 19*

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## STANDARD

**SUPER-PRECISION Spindles LEAD THE WAY IN INDUSTRY!**

**STANDARD** Super-Precision Spindles represent the ultimate in rugged construction, trouble-free maintenance and adaptability. In use on a thousand jobs in industry the nation over. Every Standard spindle is "checked out" electronically in our sound-, vibration-, dust-proof laboratory before approved for delivery. Write today for catalog.

Makers of more than 800 different Super-Precision Spindles for
**ORIGINAL EQUIPMENT MANUFACTURERS,**
**REBUILDERS**
**AND USERS**

SINCE 1912

HALLMARK OF METALWORKING
THROUGHOUT THE WORLD

**the STANDARD electrical tool co.**
SUPER-PRECISION SPINDLE DIVISION
2501 GALVIN AVE. • CINCINNATI 4, OHIO

*Circle 664 on page 19*

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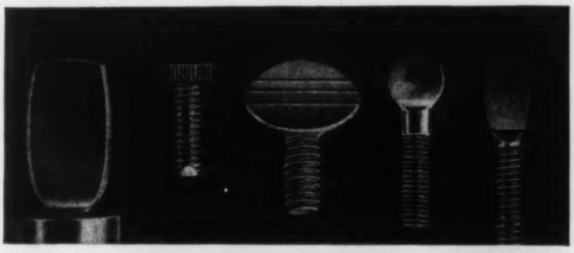
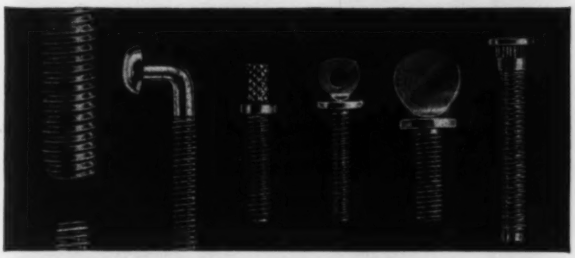
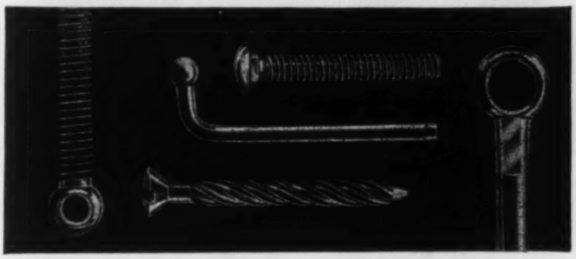


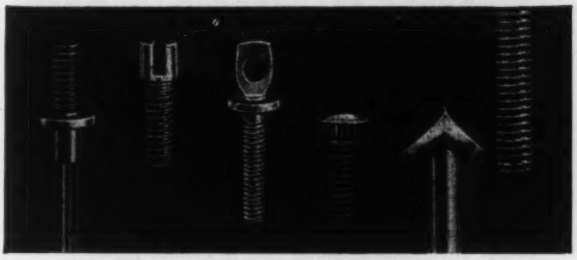
## YOU CAN'T BEAT COLD FORMING



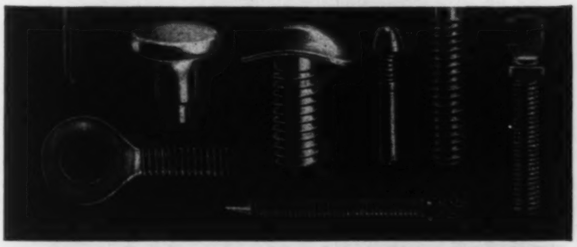
## FOR PARTS LIKE THESE—AND



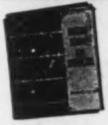
## YOU CAN'T BEAT PROGRESSIVE



## FOR COLD FORMING . . .



MACHINE SCREWS AND SPECIAL FASTENERS ARE OUR BUSINESS . . . INCLUDING SQUARE AND HEXAGON MACHINE SCREW NUTS



WRITE FOR OUR CATALOG

**THE PROGRESSIVE MANUFACTURING COMPANY**
DIVISION OF THE TORRINGTON COMPANY
52 Norwood St., Torrington, Conn.

*Circle 665 on page 19*

Presenting another NEW WISCONSIN HEAVY-DUTY Air-Cooled ENGINE

**The FULL-POWERED V-Type 4-Cylinder 30 hp. Model VH4**

This rugged new engine has been added to the Wisconsin line to fill the horsepower gap between the Model VF4 25 hp. and the Model VG4D 36 hp. Wisconsin Engines. At the same time, the mounting base is dimensionally identical to the Models VE4 and VF4 to permit convenient replacement of the latter engines if greater power is required.

The Model VH4, which now makes its bow for the first time, is the most powerful engine of its type and size available today, in our estimation. It is an engine of basic High Torque design which gives it the important advantage of being able to deliver maximum usable *Lugging Power* that carries the load through the hard, heavy pulls. It has been designed to give you the best possible performance at all engine speeds from 1400 to 2800 rpm., even when operating under intermittent shock-loads or under constant load, continuous service.

The Model VH4 is a heavy-duty engine in all respects, built for hard service under all operating conditions, at temperatures from sub-zero to 140° F. (60° C.). It is an exceptionally smooth-running, even-firing engine and has all the traditional heavy-duty features that characterize *all* Wisconsin Models, from 3 to 36 hp. It can be supplied as an "open engine" with side-mount fuel tank, or as housed power unit and may be equipped with electric generator and starter (or starter only), clutch, reduction or clutch-reduction assemblies . . . and is adaptable to operation on a variety of fuels such as gasoline, kerosene, natural gas, Butane, Propane or fuel oil of 35 Octane rating or better.

**Learn more about this new engine. Write for Bulletin S-196 for detailed data and engineering specifications.**

MOST H.P. HOURS

**WISCONSIN MOTOR CORPORATION**

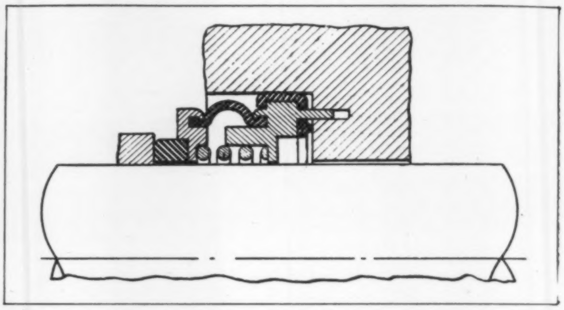
*World's Largest Builders of Heavy-Duty Air-Cooled Engines*

MILWAUKEE 46, WISCONSIN

elements while reducing friction-power losses and the size of drive motor required. *Patent* 2,765,114 *assigned to Robbins & Myers Inc. by Sheldon S. L. Chang.*

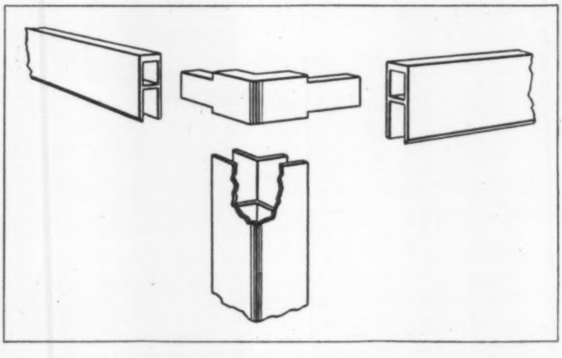
### Mechanical Seal

Lubricant leakage and dirt entry between rotating shafts and stationary housings are blocked by an end-face mechanical seal. Components (left to right) are an end-face sealing ring assembly, clamping ring, flexible sleeve, seal-mounting ring, and mounting-ring gasket. Rotation of mounting ring in the housing is prevented by projecting lugs which engage matching recesses in the housing wall. Gasket-ring, which exerts high sealing pressure against the rear of the housing cavity, eliminates need for conventional, cemented-in housing gaskets. *Patent* 2,765,186 *assigned to Chicago Rawhide Mfg. Co. by Robert D. Wright.*



### Corner Assembly

Construction of enclosures of all types, including instrument containers and electronic equipment cabinets, is simplified by an extruded corner assembly. Moisture-tight and shock resistant, the assembly is suited for use with either hollow-core or solid panels. *Patent* 2,764,314 *assigned to Skydyne Inc. by Steven E. Mautner.*



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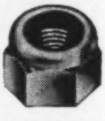
Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

**STOP-NUTS**



Black, Self-Locking,
Non-Metallic Collar

**STOP-NUTS**

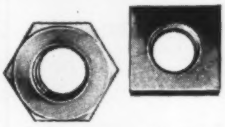
1-Piece—All Metal

**SELF-LOCKING NUTS**

Free Spinning—
Locks When Seated

**WING-NUTS**

**MACHINE-SCREW & SWITCH MOUNTING NUTS**



**CONDUIT LOCKNUTS**

Above Nuts Supplied in STEEL • BRASS • ALUMINUM • STAINLESS

*Special nuts of many types in stock*

**JACOBSON NUT MFG. CORP.**
Kenilworth 13, New Jersey

*Circle 667 on page 19*

## Here's the Answer to Accurate Timing of Electrically Operated Equipment

**ZENITH INTERVAL TIMER**

**Especially recommended for operation of blowers, pumps, agitators, mixers, conveyors and other machinery . . . widely used for plastic moulding, rubber curing, heat treating, enamel baking, light exposure and similar operations.**

**Fully enclosed. Double-throw, single-pole switch. Self-starting slow speed industrial type synchronous motor. Time range: 60 seconds to 72 hours.**

**Send for full information, including bulletin on Zenith's complete line of automatic control equipment.**

**ZENITH ELECTRIC CO.**
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*Circle 668 on page 19*

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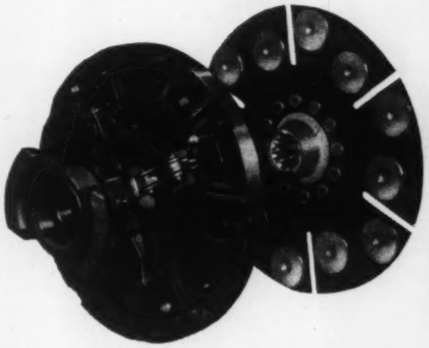
# ROCKFORD

# NEW!



# AIR-FLOW

**Heavy Duty • Over Center**

# CLUTCH

**with MORLIFE® Clutch Plate**

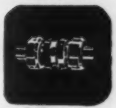
This *new* AIR-FLOW type clutch was designed to provide unusual air cooling qualities. Increased torque capacity is obtained with the Morlife clutch plate. Levers are counterbalanced to eliminate self-engaging tendencies, when the clutch is idling. An unique spring-loaded feature greatly reduces frequency of adjustment. For information how this *new* Rockford AIR-FLOW clutch, with Morlife plate, will improve the operation and increase the on-the-job hours of your heavy-duty machines, write—

BUILD BETTER ROADS TODAY FOR A GREATER AMERICA
See you at the ROAD SHOW CHICAGO Jan. 28-Feb. 2, 1957
AMERICAN ROAD BUILDERS ASSOCIATION

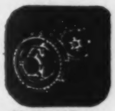
**Small Spring Loaded**

**Automotive Spring Loaded**

**Heavy Duty Spring Loaded**

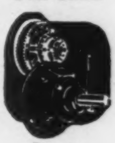


**Oil or Dry Multiple Disc**



**Heavy Duty Over Center**

**Light Over Center**



**Power Take-Offs**

**Speed Reducers**

**ROCKFORD**
**Clutch Division**
**BORG-WARNER**
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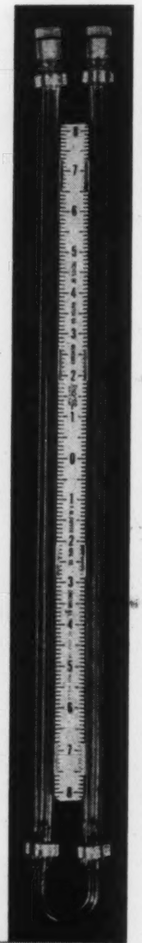
B. W. ENGINEERING MAKES IT WORK
ENGINEERING
B-W
PRODUCTION
B. W. PRODUCTION MAKES IT AVAILABLE

# CLUTCHES

*Circle 669 on page 19*

# NEW

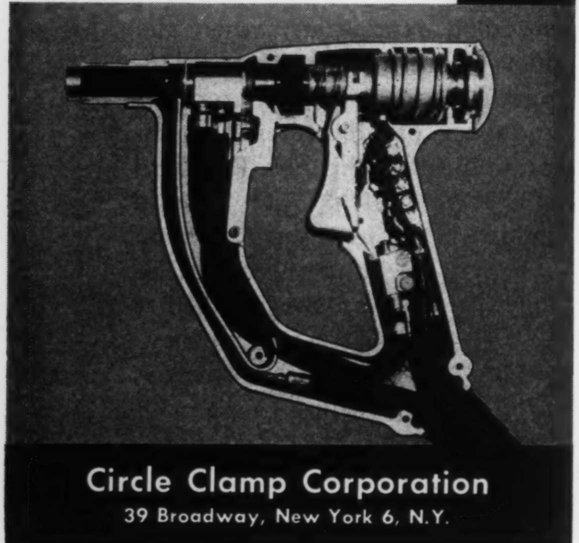
# Circle Hose Clamp... Speed, Cost & Appearance Convince Design Engineers



And CIRCLE CLAMPS provide clamping action equal to or better than any clamp available today. Actual performance and pressure tests are proving to manufacturers across the country that this new type clamp is superior to the clamps they were using. Circle Clamps in a wide range of sizes are proving lower in initial cost, faster mounting, easier to replace in the field, and neater in appearance. They accommodate all hose variations.

This Indiana manufacturer switched to Circle Clamps for its lab Manometer (right) to assure positive, non-slip holding action. Clamp assembly time of a welding gun (below) was cut from 12 to 3 seconds and maintenance almost eliminated by a New York manufacturer.

*Write for complete descriptive information, stock sizes, prices and the name of your nearby Circle Clamp Distributor.*



**Circle Clamp Corporation**
39 Broadway, New York 6, N.Y.

**2 SECOND INSTALLATION: OFF IN 1 SECOND**

Slide on!
Clamp on!
Snip off to remove!

Circle 670 on page 19

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# NEW APPLICATIONS AND SAMPLES OF INDUSTRIAL FELT*

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CONTINENTAL FELT COMPANY

*made to S.A.E. and Federal Govt. Specifications

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Circle 671 on page 19

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## Meter-Relays, VHS Relays, Simplytrol and Versatrol Automatic Controls, Panel Meters and Indicating Pyrometers

## 40 PAGE ASSEMBLY PRODUCTS CATALOG 4-A

*Contents include:*

"Circuitry"—6 pages of diagrams and text, including response time tables and discussion on non-locking contacts.

Ordering information.

**Prices and detailed specifications for:**
Clear plastic, black bakelite and ruggedized-sealed styles of:
- Meter-relays
- Indicating meters
- Indicating pyrometers

VHS Relays

Plug-in relays, power supplies

Automatic pyrometers

Automatic control packages and components

Bearing monitors

Oven pyrometers and millivoltmeters

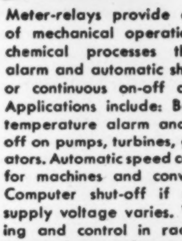
Kiln pyrometers

Shunts

Transformers

Write for Catalog 4-A.

**Assembly Products, Inc.
Chesterland 51, Ohio
HAmilton 3-4436
(West Coast: Desert Hot Springs 51, Calif. Phone 4-3133 or 4-2453.)**



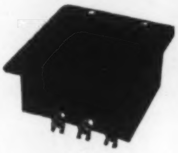
Meter-relays provide control of mechanical operations or chemical processes through alarm and automatic shut-off, or continuous on-off control. Applications include: Bearing temperature alarm and shut-off on pumps, turbines, generators. Automatic speed controls for machines and conveyors. Computer shut-off if power supply voltage varies. Warning and control in radiation measuring equipment and processes. Automatic switching of standby equipment in microwave communications. Continuous control of pH. Signal detection in radar warning systems.

Circle 672 on page 19

## *For* HEAVY DUTY WORK!

**Severest Electrical Services**

P-506-CE—Plug with Cap


S-506-DB
Socket with deep Bracket

# JONES PLUGS & SOCKETS

500 SERIES

*Proven Quality!*

**For 5,000 Volts, 25 Amperes per Contact Alterable by circuit Characteristics.**

**Socket contacts of phosphor bronze, knife-switch type, cadmium plated. Plug contacts hard brass, cadmium plated. Made in 2, 4, 6, 8, 10 and 12 contacts. Plugs and sockets polarized. Long-leakage path from terminal, and terminal to ground. Caps and brackets, steel parkerized *(rust-proofed)*. Plug and socket blocks interchangeable in caps and brackets. Terminal connections most accessible. Cap insulated with canvas bakelite.**

**Write for Jones BULLETIN 21 for full details on line.**

Jones

HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24 ILLINOIS
SUBSIDIARY OF UNITED-CARR FASTENER CORP.

*Circle 673 on page 19*

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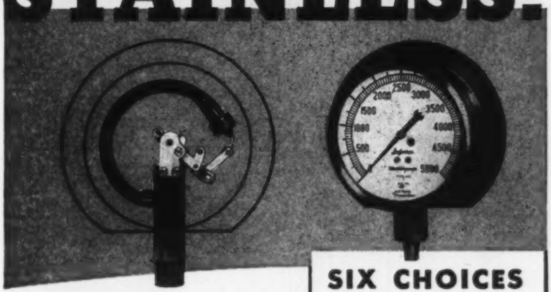
# STAINLESS!



## —from inlet to tip

Now the superlative Mastergauge is available in a wider range of corrosion resistant tubes and sockets than any other pressure gauge.

Check the adjoining list. And remember that tube socket and tip are fused into one piece by the exclusive Marsh "Conoweld" process.

Marsh alone combines the "Conoweld" construction, the copper-clad "Marshalloy" case, the finer Mastergauge movement, the Marsh "Recalibrator", the new "Safecase." Ask for data covering your specific needs.

### SIX CHOICES
***of tubes and sockets***

- **4130 alloy steel** tube with alloy steel tip and socket.
- **403 stainless steel** tube with alloy steel tip and socket.
- **403 stainless steel** tube with 416 stainless tip and socket.
- **316 stainless steel** tube with alloy steel tip and socket.
- **316 stainless steel** tube with 303 stainless tip and socket.
- **"K" Monel** tube with alloy steel tip and socket.

**MARSH INSTRUMENT CO.,** *Sales affiliate of Jas. P. Marsh Corp.* Dept. B, Skokie, Ill.
Marsh Instrument & Valve Co., (Can.) Ltd. • 8407 103rd St., Edmonton, Alberta, Can.

**MARSH** "THE STANDARD OF ACCURACY"

*Circle 674 on page 19*

---

overcome
power-spring hurdles

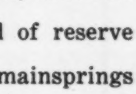
## *with* SANDSTEEL

*crosscurved mainsprings*

Obstacles to a quality product, from the product engineer's standpoint, can often be overcome with the kind of reserve power *built into* Sandsteel mainsprings with the famous *Crosscurving* process. Only highest-quality Swedish steel can be used for this concave-convex construction that enables the use of longer, thinner springs . . . while assuring the reserve power needed and a longer, more even delivery of energy.

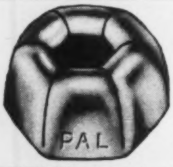
If you are designing a product requiring a flat-type mainspring, find out how Sandsteel Crosscurving can help you.

***Write for FREE LITERATURE (Springs for Your Product) and CASE FILE, Dept. 35.***



**SANDVIK STEEL, INC.**
Sandsteel Spring Division
Fair Lawn, N. J.

*Circle 675 on page 19*



# Low-cost ACORN LOCK NUTS

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Subsidiary of
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ACORN TYPE
PALNUT
TRADE MARK R
LOCK NUTS

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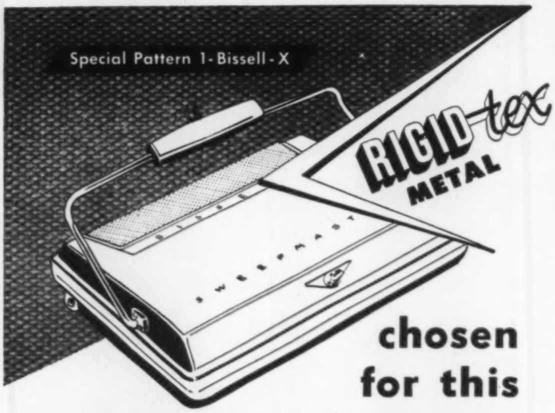

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Circle 677 on page 19

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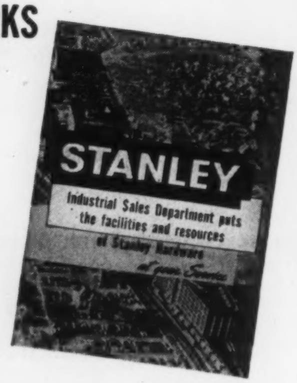

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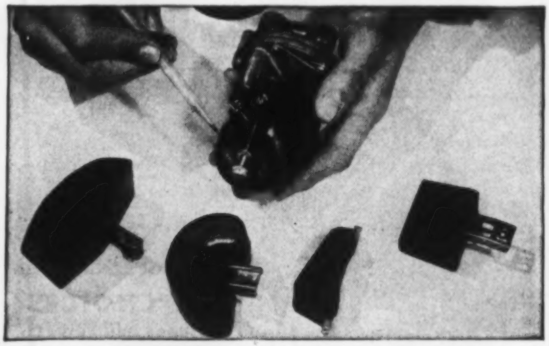

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Section 519-N
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Parker
Hydraulic and fluid system components

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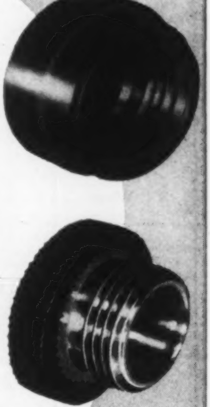
PHOENIX

BRUSH HOLDER CAPS



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Send your cap print or a sketch for prompt quotation on uniformly accurate brush holder caps to meet your requirements —or ask for Bulletin containing full details on the complete "standard customized" line of Phoenix Brush Holders and Caps.

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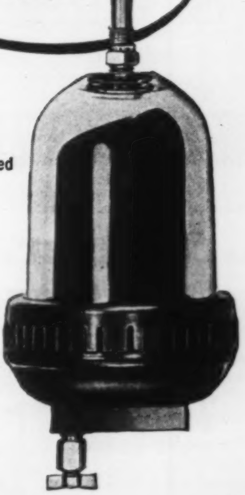

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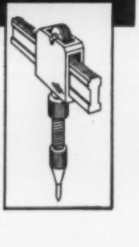

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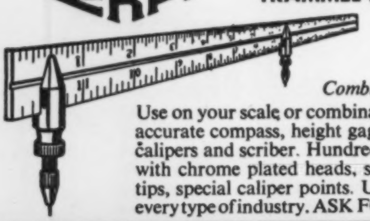

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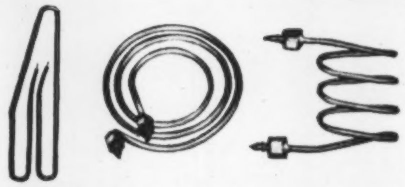

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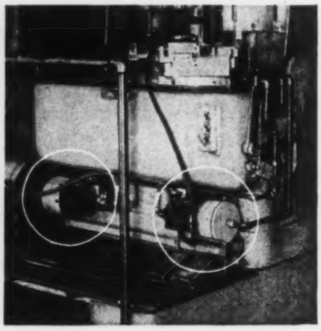

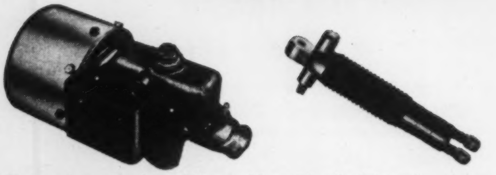

Shown above is a broaching machine with swivel type clamping fixtures, utilizing the Wagner power cluster which converts air pressure to hydraulic pressure that is delivered to actuating cylinders on each of the clamping fixtures.

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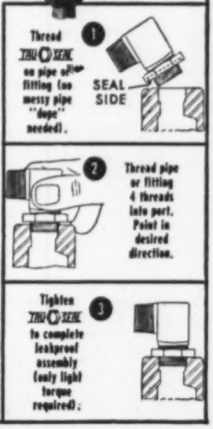

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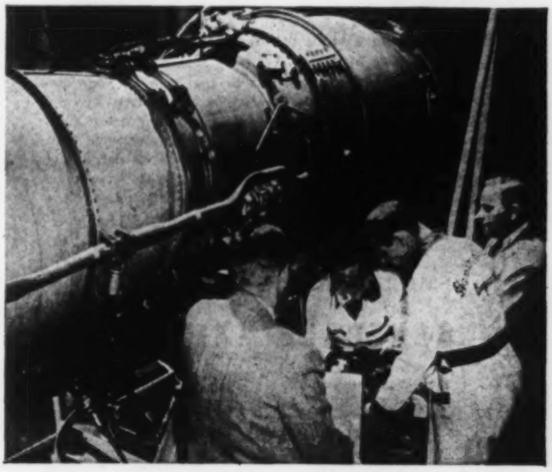

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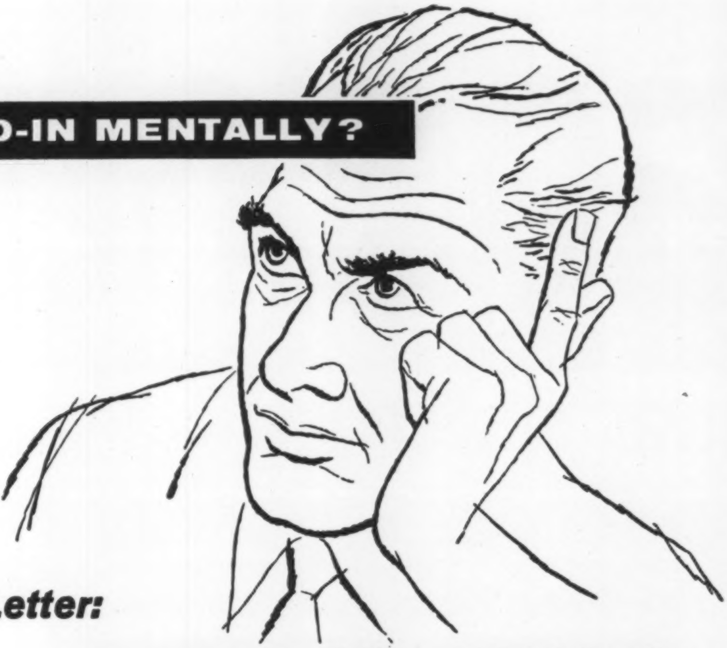

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***An Open Letter:***

**TO ENGINEERS, SCIENTISTS AND MATHEMATICIANS**

***Who Are Thinking of the Future***

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**There's a Place for You in Atomic Energy at B&W**

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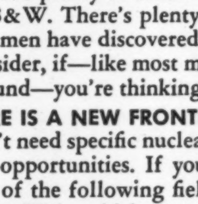

Write for literature describing some of B&W's atomic energy activities or send resume to: Personnel Department, MD-12, The Babcock & Wilcox Company, 161 East 42nd Street, New York 17, N. Y.

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**BABCOCK & WILCOX**

**ATOMIC ENERGY DIVISION**

Circle 693 on page 19

XUM

2,500,000
sink strainers couldn't be wrong

Strainer is made from [illegible] gauge x 7" Revere Leaded Brass Strip drawn to a depth of 2½".

# MICHIGAN BRASS Company saw to that by using REVERE Leaded Brass Strip

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1. The inherent corrosion resistance of brass. 2. Its deep drawing characteristics (Photo at left above shows strainer after it has been blanked and drawn in progressive die). 3. Ease of machining large diameter threads with leaded brass. 4. The excellent surface that can be developed for chrome plating (Photo above right shows strainer after it has been trimmed, dimpled, threaded and plated). 5. The consistent uniformity and quality of Revere Leaded Brass Strip over the years.

These very same characteristics of Revere Leaded Brass Strip may be the very ones that could help you retain the quality of your product over the years . . . cut your production costs. Why not have a chat with a Revere TA (Technical Advisor) and see? It costs you nothing . . . may save you plenty.

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18 01
REVERE
★ ALUMINUM ★

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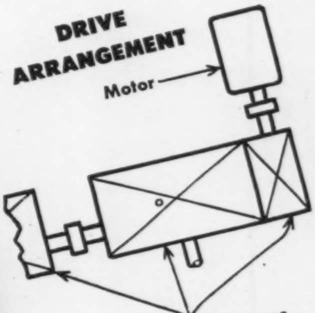
Circle 694 on page 19



**3-Cleveland Drives**

Note the small overhung reducer is transmitting power to both of the larger Clevelands—a compact but powerful drive arrangement.

# CLEVELAND-driven scarfer dresses beryllium-copper slabs

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Wherever you need to operate a machine efficiently, smoothly and economically, count on using a Cleveland. Let us send you Catalog 400 and the name of our nearest representative who is prepared to help you select Clevelands best fitted to solve your transmission needs. The Cleveland Worm & Gear Company, 3287 E. 80th St., Cleveland 4, O.

*Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.*

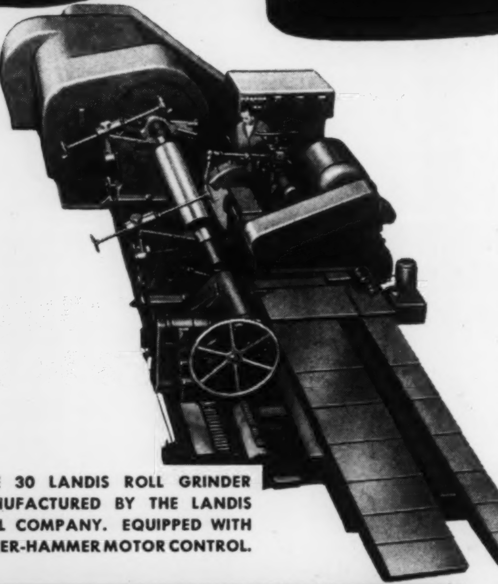
**CLEVELAND**
*Speed Reducers*

Circle 502 on page 19

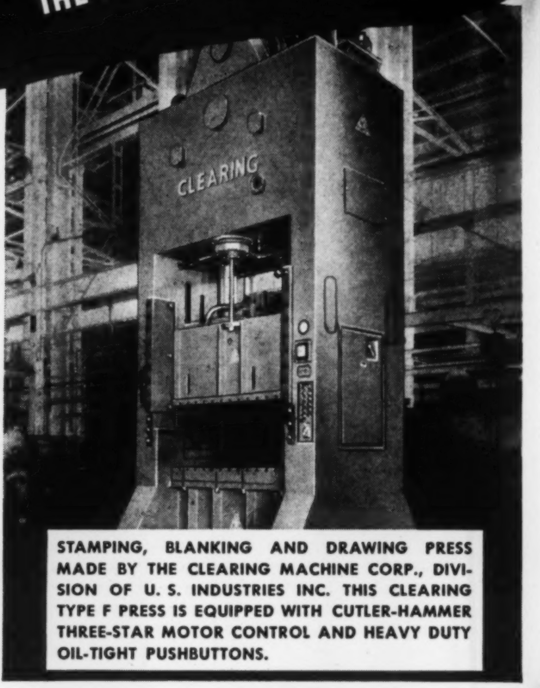
CHOICE OF THE LEADERS

**CUTLER-HAMMER**
★ ★ ★
MOTOR CONTROL
C-H

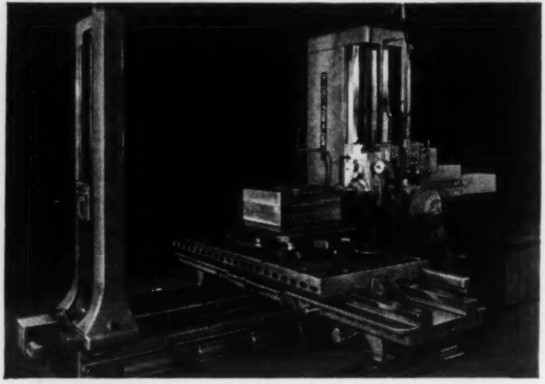
THE MARK OF BETTER MACHINES



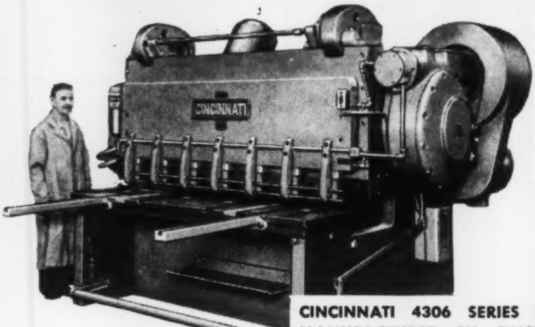
TYPE 30 LANDIS ROLL GRINDER MANUFACTURED BY THE LANDIS TOOL COMPANY. EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL.



STAMPING, BLANKING AND DRAWING PRESS MADE BY THE CLEARING MACHINE CORP., DIVISION OF U. S. INDUSTRIES INC. THIS CLEARING TYPE F PRESS IS EQUIPPED WITH CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND HEAVY DUTY OIL-TIGHT PUSHBUTTONS.



THE GIDDINGS & LEWIS 30 SERIES TABLE TYPE HORIZONTAL BORING, DRILLING AND MILLING MACHINE USES CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND HEAVY DUTY OIL-TIGHT PUSHBUTTONS.



CINCINNATI 4306 SERIES SHEAR MANUFACTURED BY CINCINNATI SHAPER CO. CUTLER-HAMMER MOTOR CONTROL IS FURNISHED AS ORIGINAL EQUIPMENT.

# "That Something Extra"

Everyone knows, "It's that something *extra* that makes the leader." This is particularly true when you refer to the leaders among machinery builders. Leading machinery builders *must* have "that something extra" to command the respect and preference of experienced buyers. Compare any leader's machines with others and "that something extra" shows clearly in one or more ways . . . finer workmanship, greater precision, more dependable performance, new and better methods and equipment for operation and control. In recent years, more and more leaders proudly feature Cutler-Hammer Three-Star Motor Control and Heavy Duty Oil-Tight Pushbuttons. Such a marked trend could only result from careful comparison that proved a definite superiority. When you buy machines, you too will find Cutler-Hammer control equipment a reliable guide to satisfaction. Now, more than ever before, Cutler-Hammer Motor Control is the choice of the leaders . . . the mark of better machines. CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin. Associate: Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

*Circle 503 on page 19*

621

DECEMBER 27, 1956
EVERY OTHER THURSDAY

# MACHINE DESIGN

A PENTON PUBLICATION

## Pivoted-Shoe Bearings

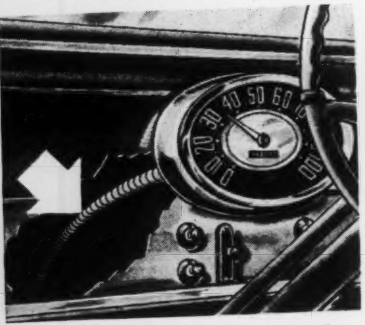
Contents, Page 3

# FLEXIBLE SHAFT IDEAS for ENGINEERS

## For driving or controlling inaccessible parts flexible shafts do a better, more economical job

### Fewer design problems, better placement of elements, easier assembly are a few of the advantages

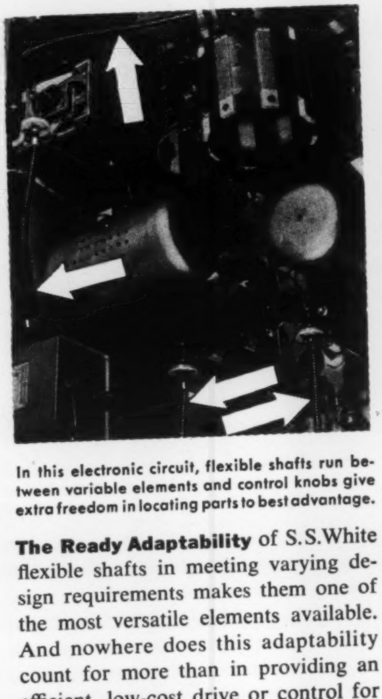
### 250,000 miles at 90 mph and still going strong



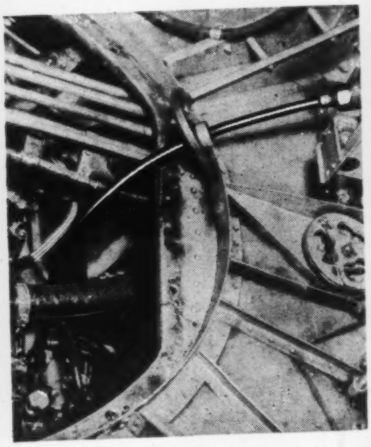
**To prove our claims** about the long life and dependability of S.S.White flexible shafts, we conducted accelerated life tests on a number of S.S.White speedometer shafts. After being run at 90 mph for 250,000 miles—the equivalent of being "driven" 10 times around the world—the shafts were still going strong.

### Here is information every designer should have

*Bulletin 5601 contains the latest information on flexible shafts. Included are full details on how to select and apply power drive flexible shafts as well as up-to-date tables showing flexible shaft sizes and characteristics.*



In this electronic circuit, flexible shafts run between variable elements and control knobs give extra freedom in locating parts to best advantage.



A flexible snaft can be easily run around obstructions from one point to another as in this aircraft tach generator drive.

**The Ready Adaptability** of S.S.White flexible shafts in meeting varying design requirements makes them one of the most versatile elements available. And nowhere does this adaptability count for more than in providing an efficient, low-cost drive or control for parts that must be mounted in hard-to-get-at locations.

*For remote control applications, this means additional design freedom in mounting controls in more advantageous operating positions. It also means more efficient placement of controlled parts to satisfy space, operating and service requirements.*

As for transmitting power, using a flexible shaft to couple a driven part directly to its driving unit eliminates the need for additional parts such as universals, straight shafts and gearing. It provides a more efficient, quieter drive which needs no alignment and which can be installed faster, with fewer problems.

*S.S.White flexible shafts are made in a large selection of sizes and characteristics to enable you to meet a wide range of application requirements.*

Full engineering cooperation in selecting and applying flexible shafts to your products is always available.

F6-7

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**S. S. WHITE INDUSTRIAL DIVISION, DEPT. 4, 10 EAST 40th ST., NEW YORK 16, N.Y.**
**Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.**

Circle 401 on page 19

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*Designers told us what industry had to have!*

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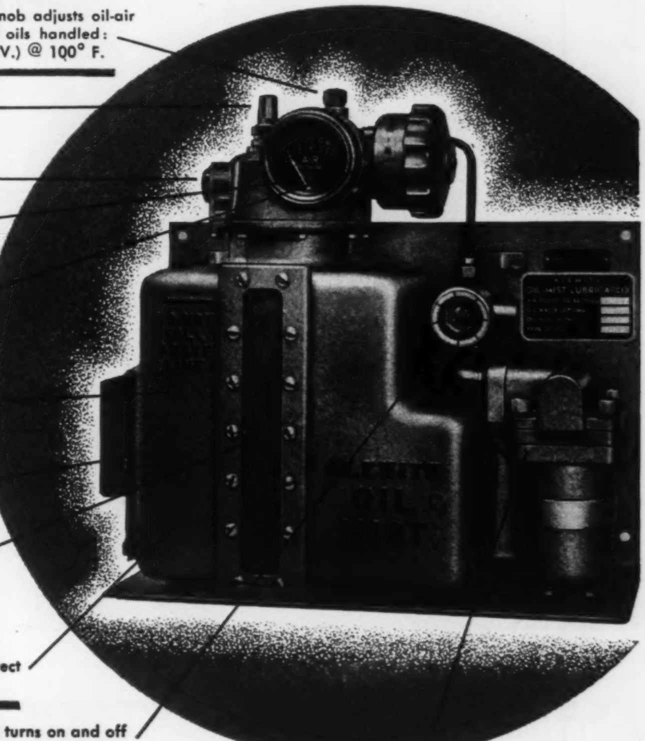

1. Oil flow control knob adjusts oil-air mixture. Range of oils handled: to 1,000 sec. (S.U.V.) @ 100° F.
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8. Nylon plastic window gives visible check of oil supply.
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10. Solenoid air control turns on and off simultaneously with machine switch.
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**Spray fittings** are recommended for open and enclosed gears and chains. Allow for a concentrated spray of oil where needed.

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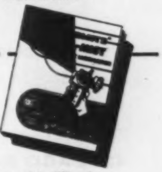
Reduces number of lubricants needed • Eliminates "Down-time"



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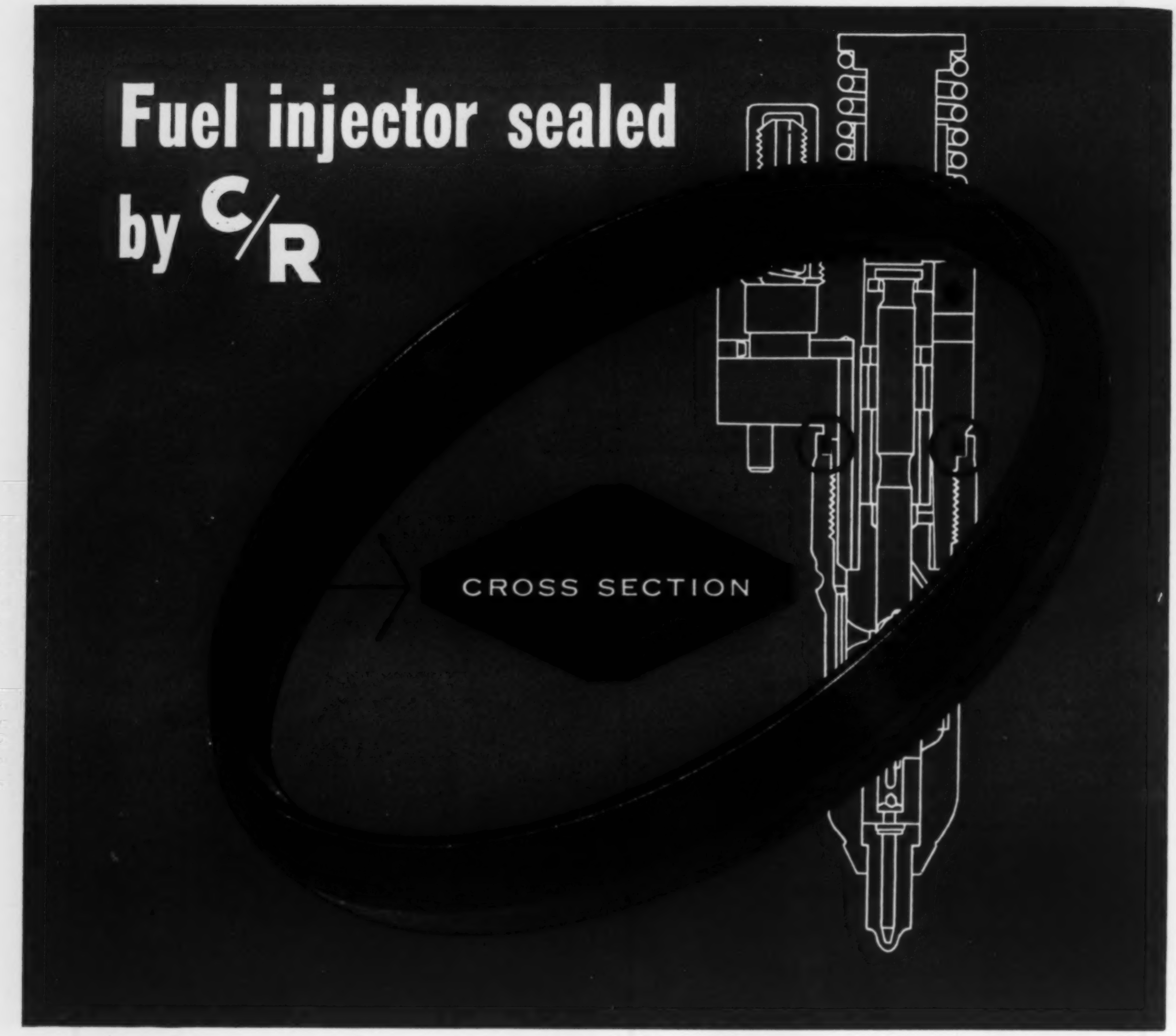
*Circle 404 on page 19*



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THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

# MACHINE DESIGN

December 27, 1956
Volume 28—No. 26

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Inside and Outside . . . entirely new
TOTALLY ENCLOSED FAN-COOLED FRAMES 284U-326U

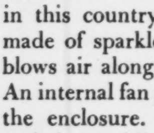
## NEW Elliott C-W type N Motor PERMANENTLY SEALED Against Dust, Moisture, Corrosive Fumes

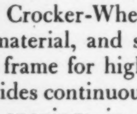
The rugged "Sealedpower" cast frame Elliott motor shown above is the modern version of the design pioneered in this country by Crocker-Wheeler. An external fan, made of sparkless material, and surrounded by a cowl, blows air along the frame for highest cooling efficiency. An internal fan provides continuous air circulation within the enclosure. All openings in the frame are tightly sealed, providing complete protection to windings and working parts.

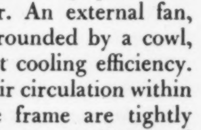
Once applied only in locations where extremely destructive atmospheric conditions prevail, totally-enclosed motors are today rapidly gaining acceptance for all types of applications. Users find that the total over-all cost—first cost plus maintenance—is less than that of open or semi-enclosed motors.

Ask your Elliott representative for details, or write for the new type N motor bulletin. Address Elliott Company, Crocker-Wheeler Division, Jeannette, Pennsylvania.

OTHER C-W TYPE N MOTOR ENCLOSURES


**Totally-enclosed non-ventilated**


**Dripproof Protected**


**Totally-enclosed, fan-cooled Frames 256 U and smaller**

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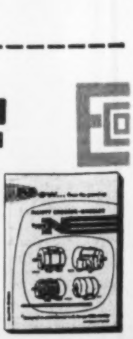


**We will be glad to send a copy of this new booklet describing the complete line of Elliott C-W type N motors. Please write on company letterhead.**

W6-6

*Circle 406 on page 19*

# Engineering News Roundup

## *Council Seeks Action on Shortage of Engineer Aides*

PAOLI, PA.—Engineering support personnel are just as scarce as engineers themselves, and concerted action must be taken immediately to remedy the situation. These were the observations of 280 representatives from industry, education and government who met recently at the Research Center of the Burroughs Corp. They comprised a Workshop of the Design and Drafting Council of the Delaware Valley. Their objectives were immediate plans and a long-range program for relieving current pressing shortages of draftsmen and engineering aides.

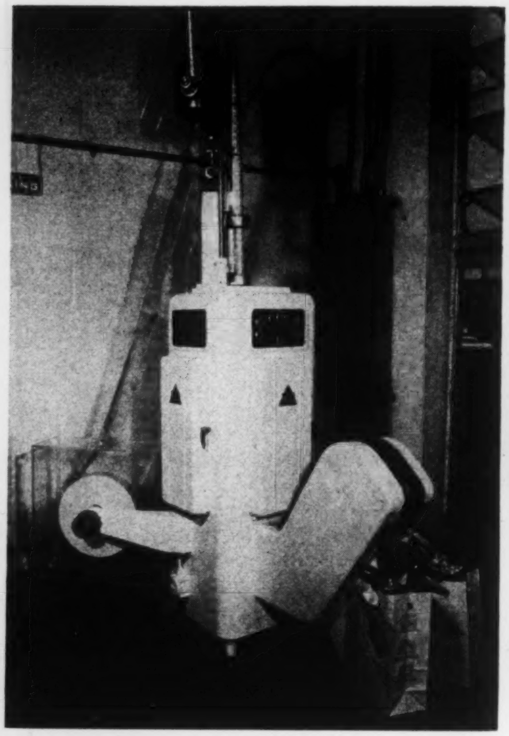
The Council finds that while the need for engineers has been widely publicized, little attention has been focused on the diminishing supply of "second echelon" personnel. This second echelon is composed of draftsmen and technicians urgently needed to fill support jobs currently done by engineers.

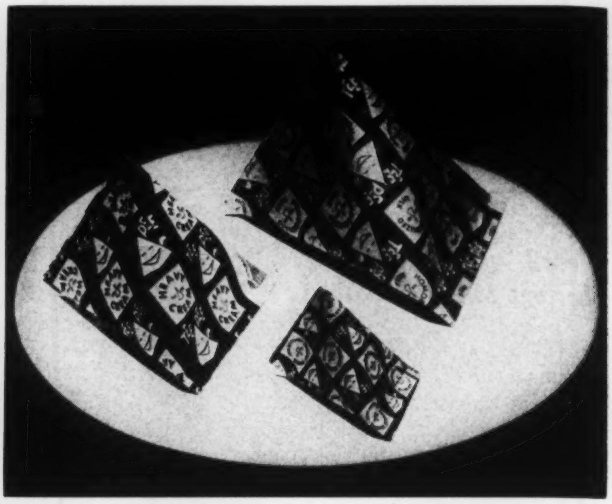
Thomas W. Hopper, executive vice-president of Day & Zimmerman Inc., told Council delegates that it has been estimated in Philadelphia "the cost of advertising for draftsmen and designers has amounted to almost $25,000 per week." Time has proven that this apparently is not the answer, or an effective approach to solution of the over-all problem.

Panel discussions at the Workshop sought recommendations for immediate partial solutions and ultimate complete solutions to the support personnel shortage. Subjects under discussion in the panels included pre-industry training in schools, the place of training in the design and drafting fields, specialized training for upgrading, the means by which training programs can be sold to management, training for drafting supervisors, and specialized training for work peculiar to operations.

Delegates to the Workshop recognized that the development foundation for skilled workers must be in the junior, senior, vocational,

EQUAL TRIANGLES are assured with this new equipment developed by Convair to machine simultaneously, in pairs, the delta wings for F-102A jet interceptors. The combination tool and fixture is 169 in. wide, 361 in. long and 252 in. high. Here it performs the first of three operations—trimming the wing skins along the leading edge spar. The trim is 31 ft long; held straight and parallel to ±0.010-in. The trim is cut by four ½-in. diam end mills driven at 22,000 rpm by air turbines mounted on a bridge assembly. The bridge is driven up and down the bed by its own motor geared with a rack in the machine bed. Automatic switches limit bridge travel.





MILK IN PAPER PYRAMIDS, called Textra Paks, is the product of this Swedish machine recently introduced in the U.S. for the first time. A roll of paper lined with polyethylene is formed into a tube, pinched at the base, filled with liquid, then pinched again at right angles. Cutters separate individual units. The absence of air in filled containers helps the product keep longer. The packaging method permits economical marketing of dairy products in small units.

and technical high schools. It was recommended that courses of instruction be concentrated on basic drawing mechanics and techniques, a good command of basic mathematics, a general knowledge of materials, and particular emphasis on accuracy.

It was also suggested that overage personnel with years of experience in the fields of design and drafting be encouraged to reenter the drafting room, or utilize their specialized "board" experience in teaching these fields in the public schools.

HIGH STYLE AFLOAT is this new cruiser called the Caribbean, one of 12 new models with similar lines introduced by Lone Star Boat Co. The 19-ft hull is Fiberglas and available in 7 two-tone color combinations. Intended for family fishing, camping and cruising, the Caribbean has twin built-in bunks upholstered with foam rubber and a pilot seat convertible to a drop leaf table. Heaviest recommended outboard motor for the boat is 150 hp.

## *"Hot" Metals Now Examined With Remote Microscope*

RICHLAND, WASH.—A remote controlled microscope developed by G-E for the Hanford plutonium plant is now being used to inspect materials giving off radiation that makes direct examination impossible.

The instrument enables the study of changes in microstructure that occur when metals are exposed to chain reaction bombardment. The pieces exposed to radiation become ray emitters themselves.

The sample is manipulated remotely inside a 38-ton steel cell by means of mechanical "hands" powered by electric motors. Elec-

### *Front Cover*

**Pivoted-shoe bearings have one unique feature: they are self-aligning, since the shoe can tilt to compensate for differences in load on the journal. Also, oil film whirl is eliminated, and abrasive "lubricants" can be handled easily. George Farnsworth's cover keynotes E. J. Cattabiani's article on pivoted-shoe bearings on Page 63.**

a new material

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**Circle 407 on page 19**

XUM

trical etching equipment removes the top layer of metal which has been made into a "nontypical microstructure" by heat of the grinding.

Light beamed through a wall port is focused to a bright pin point on the polished sample. Reflected light from a circular dot of metal, sometimes as small as 0.005-in. diam, is collected by a compound lens and projected through another wall opening to an external eyepiece. There, it is transformed into a vastly enlarged image of the circular area.

The instrument can optically separate two elements of grain structure 0.001-in. apart. In effect, it places the observer's eye within 0.004-in. of a "hot" surface. The microscope protects the observer from radiation but it becomes damaged itself in the process. Its optics are said eventually to go "blind."

NEITHER SNOW nor mud nor underbrush stops the LeTourneau Transporter, which can climb steep embankments and travel over rough terrain. Designed to carry freight in areas not served by highways, it has a load capacity of 70,000 lb. The vehicle itself weighs 55,000 lb. Individual electric motors drive each wheel, and if one wheel loses traction its power is transferred to the others. The braking system utilizes regenerative action of the electric motors in the wheels. One control governs speed, power and braking. Electric steering is controlled by pushing a finger switch left or right.

## *Survey Finds Engineers Don't Want Engineer Unions*

NEW YORK, N. Y.—Engineers have expressed strong opposition to engineering unions in a survey conducted recently by *Industrial Relations News.* The survey covered 633 engineers in companies of 1000 to 3000 employees located in northeastern and midwestern U.S.

Asked if they felt they were part of management, 50 per cent of young engineers 21 to 30 said "yes". The percentage increased with age.

At least 75 per cent of engineers of all ages said they would rather rely on their own initiative for their economic welfare rather than a union. Largest numbers who thought unions a definite hindrance were in the youngest age group.

The survey showed that differences between engineers in management and those in technical work exclusively were felt most keenly by young men and progressively less with age.

Half of the engineers thought that the existence of engineering unions had changed their status, and three-fourths of these thought the change was for the worse.

Asked, finally, if they believed in engineering unions in principle, 85

## Topics

**National Engineers' Week,** to be observed February 17-23, 1957, has as its theme "Engineering—America's Great Resource." Purpose of the event is to bring before the public contributions which the engineering profession has made to modern living. Sponsors also hope that publicity given the observance of this week will encourage young people to enter the engineering profession.

• • •

**Portable P-A system** fits into a 14 by 18 by 6-in. case, weighs 18 lb. Components include a transistor amplifier, an 8-in. speaker and microphone. The system is rated by its manufacturer, Antrex Corp., as capable of handling an area of about 6000 sq ft without auxiliary speakers.

• • •

**New engineering curriculum** has been announced by Pratt Institute. A common two-year course of study will be followed by students in electrical, mechanical, industrial and chemical engineering. Emphasis will be on mathematics and science without specialization, except in the junior and senior years.

• • •

**Speech compressor** has been developed by an engineer at Temco Aircraft Corp. to squeeze the human voice into a narrow range for improved radio transmission. The transistorized unit compresses peak values of voice sounds to a 24-decibel limit which serves the needs of communication. Interference from background noises is reduced.

• • •

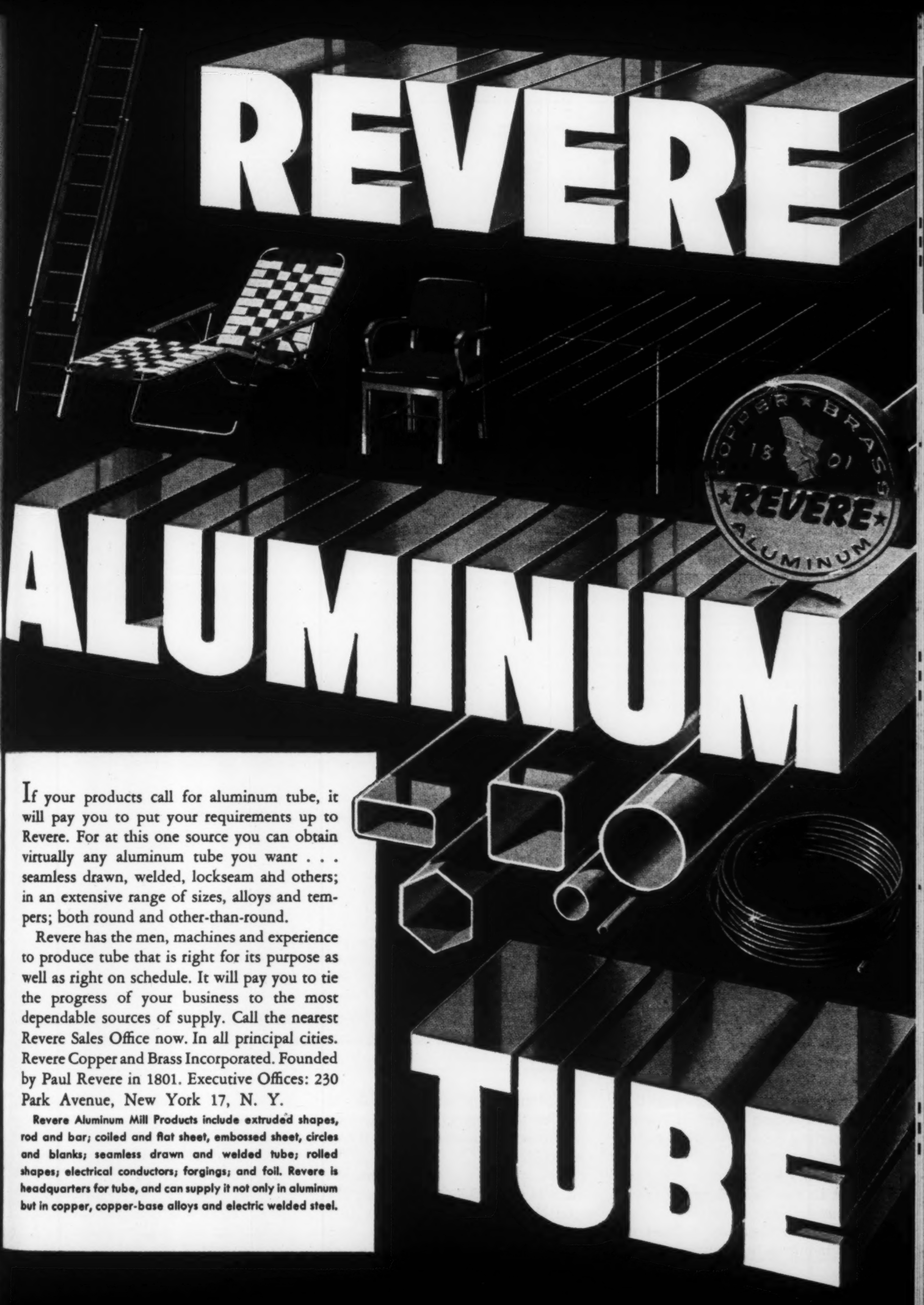
**Cooling with gas** is possible with equipment developed by the Le Roi Div. of Westinghouse Air Brake Co. Engines which burn natural gas power 75 to 500-ton air conditioning units. Advantages claimed for the use of gas are operating economy and automatic operation at variable speeds to meet cooling requirements.

• • •

**First American supersonic bomber,** the Convair B-58 Hustler, was reported "outstandingly successful" in its first test flight. The delta-winged B-58 is powered by four GE J-79 turbojet engines with afterburners. It is designed for altitudes above 50,000 ft.

Circle 408 on page 19→

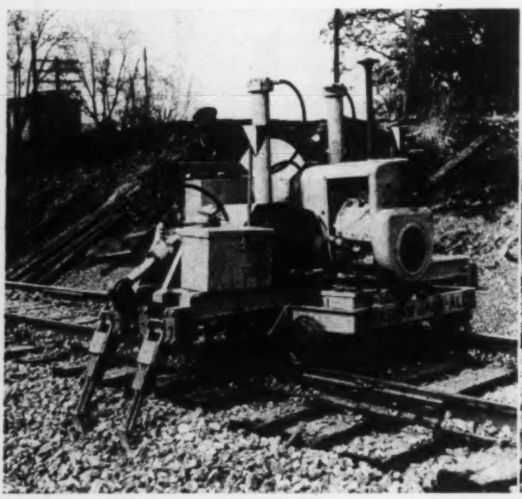
# REVERE ALUMINUM TUBE

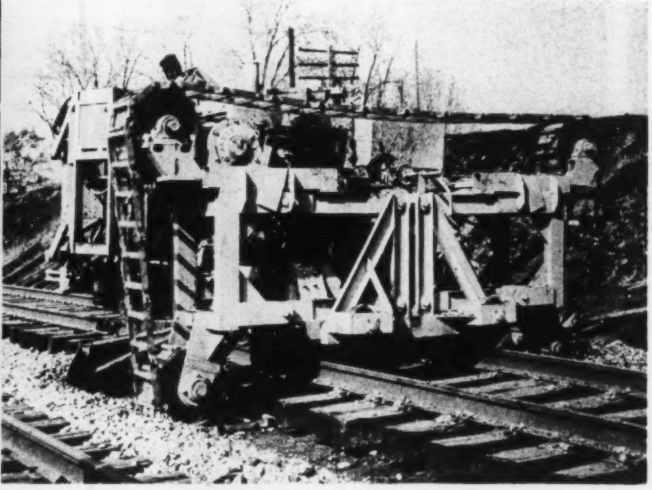


If your products call for aluminum tube, it will pay you to put your requirements up to Revere. For at this one source you can obtain virtually any aluminum tube you want . . . seamless drawn, welded, lockseam and others; in an extensive range of sizes, alloys and tempers; both round and other-than-round.

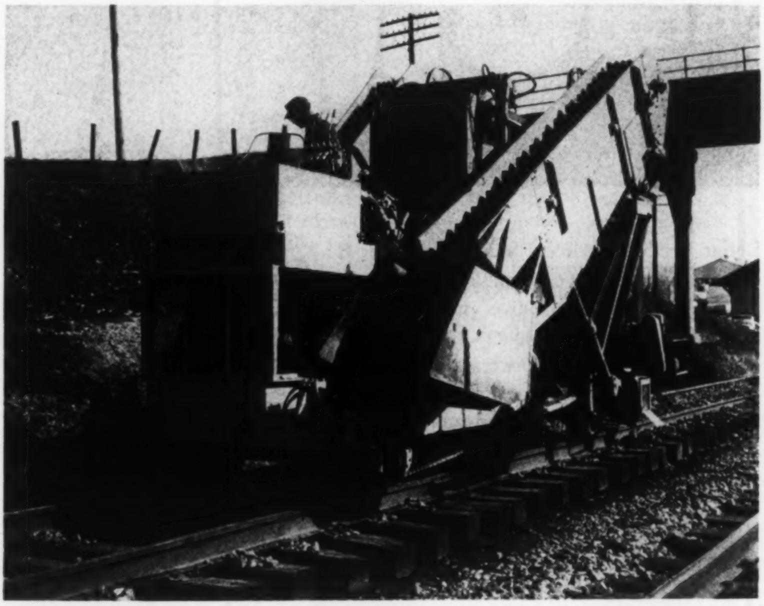
Revere has the men, machines and experience to produce tube that is right for its purpose as well as right on schedule. It will pay you to tie the progress of your business to the most dependable sources of supply. Call the nearest Revere Sales Office now. In all principal cities. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801. Executive Offices: 230 Park Avenue, New York 17, N. Y.

**Revere Aluminum Mill Products include extruded shapes, rod and bar; coiled and flat sheet, embossed sheet, circles and blanks; seamless drawn and welded tube; rolled shapes; electrical conductors; forgings; and foil. Revere is headquarters for tube, and can supply it not only in aluminum but in copper, copper-base alloys and electric welded steel.**





MECHANICAL BEDMAKERS on railroads now do the hard work in track maintenance that cuts wear and tear on cars and cargoes. These new units, made by Kershaw Mfg. Co., were recently demonstrated on the Erie road. A Jack-All unit (left) raises rails and ties as much as 7 in. to restore original track elevation, then tamps ballast temporarily to hold the new position. Its two hydraulic rams can be operated independently to provide elevation differences between rails on curves. An undercutter (right) clears up to 5 in. of old ballast from beneath ties. Its cutting chain arms withdraw in 30 seconds to pass traffic on adjacent tracks. Cleaner (below) picks up old ballast, shakes it free of dirt and redistributes the stone under the ties. Gangs of these machines and others will recondition 500 ft of track per hour at 300 per cent labor savings over manual methods.



per cent of the sample replied no. Even among engineers in large companies, the reply was 80 per cent no.

## Mechanical Literature Searching Uses Coded Technical Abstracts

CLEVELAND, O.—A method of literature searching which employs a mechanical searching selector and coded abstracts of technical matter has been described in recent technical sessions of the Special Libraries Association by Allen Kent, associate director of the Center for Documentation and Communication Research, Western Reserve University. The method and the equipment are early results of a project financed by the American Society for Metals to determine whether an operating literature searching service is feasible.

Starting point for designing the equipment was the realization that documentation systems are called upon to meet a wide variety of information requirements. These range from narrowly defined specific inquiries to comprehensive descriptions. Further analysis revealed that any given requirement involves a combination of several concepts.

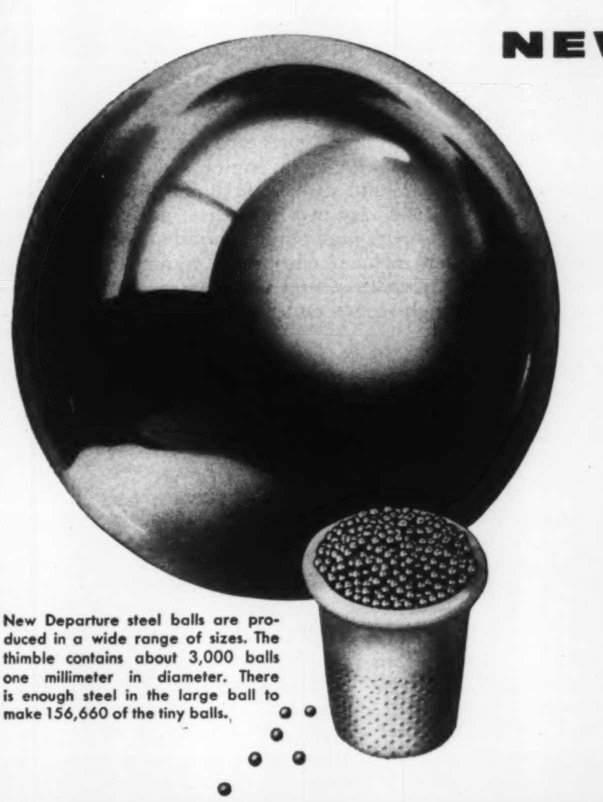
In operating the system, abstracts of technical papers are first converted into a telegraphic form of standardized terminology. Each of the standard terms is then expressed in a code of letters and symbols suitable for posting on punched paper tape.

A requirement for information is expressed the same way the original abstracts were prepared. The Search Selector scans the tape, comparing the requirements with the contents of encoded documents.

# FACTS

about

## NEW DEPARTURE STEEL BALLS



New Departure steel balls are produced in a wide range of sizes. The thimble contains about 3,000 balls one millimeter in diameter. There is enough steel in the large ball to make 156,660 of the tiny balls.

### Available in any quantity to fit your specifications for grade, size and accuracy!

When industry wants steel balls of proven accuracy and dependability, it is only natural that they turn to New Departure, leading producer of ball bearings and therefore thoroughly experienced in the manufacture of precision balls. Today, New Departure provides industry with high-carbon chrome and stainless steel balls in a wide range of sizes and specifications.

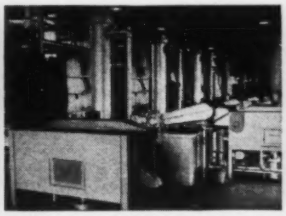
New Departure balls are produced from the finest high-carbon chrome steel. AISI Type E51100 steel, specially made for New Departure, is heat-treated to achieve the proper hardness and toughness for maximum strength and life in the finished product. Stainless steel, AISI Type 440C, used by New Departure results in balls of much improved hardness and load-carrying ability.

In addition to producing the finest steel balls available, New Departure will fill volume orders for balls of special materials such as high-nickel or cobalt-base alloys, tool steel and others.

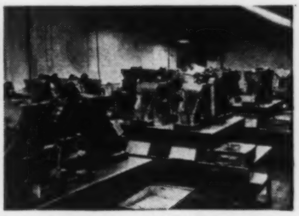
NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

Steel ball wire is drawn through dies to assure uniform diameter and roundness.

Precise control of grain flow is obtained with these Ball Heading Machines.

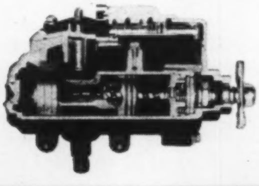


Balls are heat-treated, quenched in oil or water, then tempered in electric furnaces.

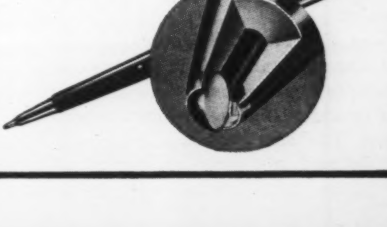


These gauges sort balls into lots according to required diameter limits.

### Applications range from power steering to pencils



The unique advantages of New Departure steel balls are utilized in many applications ranging from heavy-duty bearings to the new liquid lead pencil. To accommodate these applications, New Departure steel balls are offered in sizes ranging from .025 inch to 1⅞ inches in diameter.



Circle 409 on page 19

Where the two match, the selector types the serial number of the document.

For example, an abstract composed in conventional language reads, in part, as follows:

> **Alterations in Cast-Iron Properties Accompanying Use of a Strong Inoculant of the Si-Mn-Zr type.** C. O. Burgess and R. W. Bishop. *Trans. Am. Foundrymens' Assoc.* Preprint No. 44-16, 35 pp. (1944).
>
> A study of the effect of ladle treatment on the Brinell hardness, tensile strength, tranverse strength and chill depth of 2.5 C, 3.0 C, 3.5 C unalloyed gray irons, each group varying in Si content from 1 to 2.5 per cent.

Expressed in standardized telegraphic form, the same abstract reads:

> *Serial No.* 00190190 *Authors* C. O. Burgess and R. W. Bishop. *Trans. Am. Foundrymens' Assoc.* Preprint No. 44-16, 35 pp. (1944). *Field,* Ferrous metallurgy. *Starting material, Material processed, Properties given for* Gray iron *containing* 2.5-3.5 C and 1-2.5 Si. *Properties* Tensile strength, transverse strength, Brinell hardness, chill depth. *Process* Ladle treatment.

Examples of codes for elements of the telegraphic abstract are: DCT/ for "Document reference (namely)" and TRAMFRMAS for "Trans. Am. Foundrymens' Assoc."

Converted to code form, the abstract appears thus:

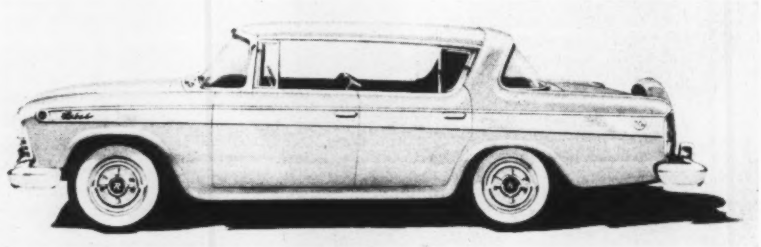
```
SN00190190ATR/C. O. BURGESS:
R. W. BISHOP DCT/TRAMFR
MAS;PPT44-16PP35YR1944LOKSA
CNMYTL 01 KALRYRN01KAJKEJ
KOVRARN04KUJ&C&/2.5%3.5%&
Si&1%2.5%KWVPAPR48PAPR55
PAPRMYTL11.
```

The standardized terminology is an extension of conventional subject indexing and classification. Combinations of the standard terms permit expression of complex concepts in the same way that words in conventional language form phrases, phrases form sentences, and sentences form paragraphs.

The Searching Selector permits an exceptionally wide range of concepts to be used in defining and conducting searching operations. The scope of a search may be defined not only in terms of

## *Three More 1957 Automobiles Announced*

CHRYSLER MODEL 300-C, a 54.7-in. high sports-type automobile, develops 375 hp at 5200 rpm. It is powered by a 392-cu in. engine with 9.25 to 1 compression ratio and 4.0 by 3.9-in. bore and stroke. Maximum torque is 420 at 4000 rpm. Other features of the 300-C are two four-barrel downdraft carburetors, dual paper-element air cleaners, high-output camshaft and dual exhaust system. Standard equipment includes pushbutton transmission, power steering, 14-in. white sidewall racing tires, and total-contact power brakes. Front brakes are air-cooled through scoops under the dual headlights.



FOUR-DOOR HARDTOP RAMBLER REBEL will be available with an electronically controlled, transistorized fuel injection system. Heart of the system is an electronic unit which gathers information relative to fuel requirements, correlates the information along with timing data received from the distributor, then meters the fuel charge. The 237-cu in. V-8 engine equipped with this Electrojector system develops 288 hp; with the standard four-barrel carburetor it is rated at 255 hp. Compression ratio is 9.5 to 1; bore and stroke are 4 by 3¼ in. Color of the car will be silver-gray.

MERCURY'S TURNPIKE CRUISER introduces a ventilating system comprising roof-level fresh air intakes and a power-operated retractable rear window. Other power equipment includes steering, brakes, windows and Seat-O-Matic, which automatically positions the seat in response to a selection dialed on the instrument panel. The car has Quadri-Beam dual headlamps, air-cushion rear suspension, full-cushion shock absorbers and a clock that automatically computes elapsed time and mileage, permitting rapid calculation of average speed for given distances. Engine is 290 hp with 368 cu in. displacement and compression ratio of 9.75 to 1. Turnpike Cruisers will be made in two and four-door hardtop body styles.

# Design data on adhesives

(Advertisement)

**Armstrong**
ADHESIVES • COATINGS • SEALERS

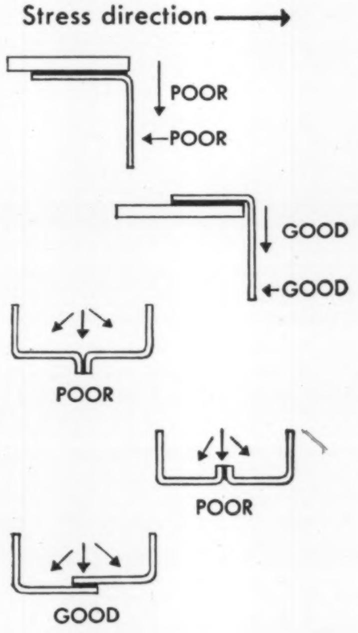
NUMBER SIX

### Designing joints for flexible materials

When sheets of flexible materials are to be bonded to metal, the joints should be designed with the adhesive in shear wherever possible. Joints where the adhesive is in peel are generally less desirable and may fail when stress is applied.

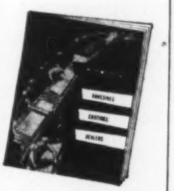
In assembling thin gauge sheets to metal, particularly when bonded behind the metal, the sheet should be overlapped as illustrated to place the adhesive in shear. The overlap should be adequate to place minimum unit stress on the adhesive.

The drawings below illustrate plastic or rubber sheet bonded to metal in shear and peel, and flexible plastic bonded to itself.



**For more information**

Write for a copy of "Armstrong Adhesives, Coatings, and Sealers." Armstrong Cork Company, 8012 Dean St., Lancaster, Penna.



## How to bond flexible materials

The first thing to be considered in bonding flexible materials is the design of the joint. Four rules, basic to all adhesive joints, must be observed:

1. Make the bonded area as large as possible.
2. Make the maximum proportion of bonded area contribute to strength.
3. Stress the adhesive in the direction of its maximum strength.
4. Minimize stress in the direction in which adhesive is weakest.

### Design in Shear

Adhesives for bonding rubber vary widely from soft, tacky products to rather hard, rigid thermosetting resins. Although the rubbery adhesives generally have good peel properties, joints should be designed in shear rather than in peel where possible, as shear strength is higher.

**BONDING FLEXIBLE COVERING** to a steel loom roll. Adhesive is spread on the roll which is chucked in a lathe. Covering is taped on at one end, then fed on the roll, which turns at 10 rpm.

To minimize the unit stress on the adhesive, overlap should be adequate when bonding sheets of thin rubber or plastic to metal. And during assembly, tension in the sheets should be kept at a minimum, since it can result in residual constant stress on the adhesive.

### Edge-Joining

Edge-joining sheets of thin flexible material may be accomplished by a simple lap joint, or they may be butted and a strap of the same material or of cloth applied over the seam. Butting sheets of heavier gauge is not practical, since butt joints in tension generally have inadequate strength.

Scarf joints have been found to be a practical solution to edge-joining of heavy sheet material. They are especially useful for strips of rubber from 3/16-inch to 3/8-inch thickness or heavier, which often require splicing or fastening to form corners, as, for example, in making gaskets. (Length of a scarf joint in rubber should be at least four times the thickness.)

### Heavy Materials

Motor mountings and roll coverings frequently involve the adhesion of heavier sections of rubber or flexible materials to metal. Under severe loading, with rubber roll coverings which allow stress to be translated through the rubber to the adhesive, failures may be minimized by improving stress distribution in the rubber next to the adhesive bond by increasing rubber hardness at the inner diameter, or by using cloth interliners.

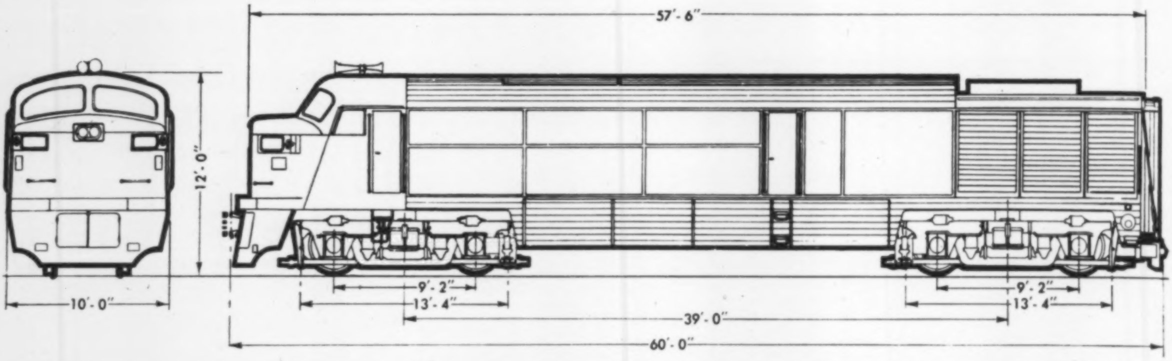
### Rubber-to-Metal

In rubber-to-metal or other flexible-rigid assemblies, stress concentrations can be minimized through the elimination of sharp corners. The metal should be thick enough to prevent peel stresses which may occur with thin-gauge metals. Sharp changes in section in the rubber or plastic can also result in stress concentrations.

Loading beyond the capacity of the bonded assembly can result not only in adhesive failures, but also in short life of the assembly due to rubber fatigue and failure. Depending on permissible cost and performance requirements, it may be possible to eliminate over-stressing in some applications by providing a bumper which comes into compression when a given deflection is reached.

Rubber-to-metal assemblies in shear or tension loading may be designed at about 50 psi and in compression at about 250 psi, although these loadings depend to a great extent on the application involved, the type of rubber, and the adhesive.

Circle 410 on page 19



Speed Merchant locomotives at each end of the New Haven's new train between New York and Boston operate on diesel or third-rail electric power.

specific substances, devices, attributes, processes, conditions, organisms, persons, locations, etc., but also in terms of generic concepts and their relationships to specific terms.

## Fuel Production to Double In Twenty Years

NEW YORK, N. Y.—Production of fuels in America will double in the next 20 years, according to Dr. Clyde Williams, president and director of Battelle Memorial Institute. Dr. Williams recently told members of the ASME that coal production will reach one billion tons by 1975 and that increased demand will result in greater use of synthetic liquid fuels and fuel gas manufactured from coal and shale.

Factors contributing to future demand are:

1. Population increase. The Census Bureau forecast for 1975 is 228 million.
2. Improved standard of living. Gross national product should reach $870 billion by 1975, more than double the present $414 billion.
3. New methods of production and fabrication requiring more energy per unit of weight or volume. Production of aluminum requires more energy than many of the materials it is replacing. Synthetic building materials, plastics and fibers use more energy than natural materials.
4. Increased electrification of homes, offices, factories and farms.
5. Increased mechanization and other changes in processing in the iron and steel industry.

## Paired Engines Push-Pull Double-Ended Shuttle Train

NEW HAVEN, CONN.—A new five-car train of the Talgo type has been placed in service by the New York, New Haven and Hartford Railroad on the run between Boston and New York. Named the Daniel Webster, the train has locomotives at both ends.

The train can be reversed at the ends of its run without actual turning around, as on loop track, or without uncoupling the locomotives. Also, at the New York end, the locomotives are convertible from diesel power to third-rail electric power.

General data for the locomotives are:

| Weight | |
|---|---|
| Total fully loaded (lb) | 216,000 |
| Total on drivers (lb) | 110,000 |
| Per axle (lb) | 55,000 |
| **Performance** | |
| Starting tractive effort @ 30% adhesion (lb) | 33,000 |
| Continuous rated tractive effort @ 23.5 mph (lb) | 15,000 |
| Maximum speed (mph) | 117 |
| Minimum radius of curvature (ft) | 212 |

Prime mover in each locomotive is an eight-cylinder Fairbanks Morse opposed-piston diesel engine. The engine drives a main traction generator through a flexible coupling. The diesel engine is operated at constant speed of 850 rpm and variable load. The application is analagous to a stationary steam power plant.

In contrast to the majority of diesel-electric locomotives operating on domestic railroads, the engine-room space is a pressurized plenum chamber and is used to supply the air requirements of the engine, the self-ventilated main generator and the air compressor.

Provision of the plenum chamber is considered to be highly pertinent in the case of the trailing locomotive which encounters the dust or snow raised from the roadbed by the leading locomotive and the cars.

Two GE-752 motors are used for traction purposes on each locomotive. For third-rail applications the standard motor is slightly modified by the addition of a ground return current path to bypass the 600-volt propulsion current around the locomotive journal bearings.

During third-rail operation, automatic resistor control is provided for smooth acceleration in 12 steps under control of a current relay. While this type of equipment is commonly used on multiple-unit cars operating on third-rail power, this is believed to be its first use on road locomotives in the U.S.

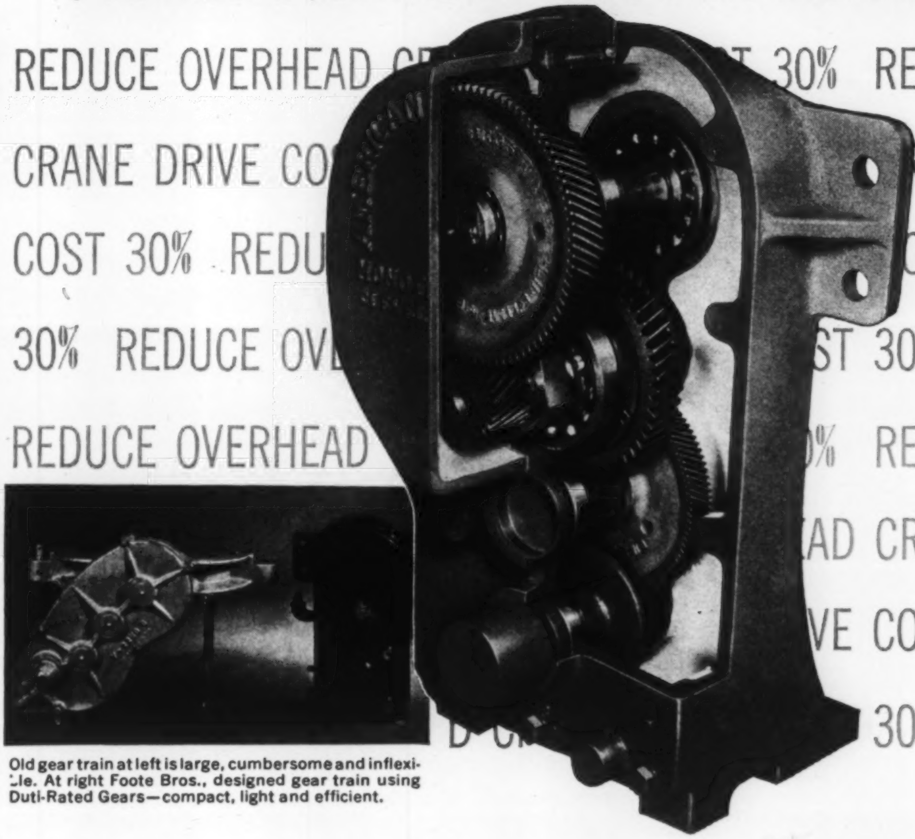
## Atom Arms Must Be Built Sure-Fire and Maintainable

NEW YORK, N. Y.—"Atomic war has not been stalemated to the degree that we can afford to tailor our military forces primarily to the requirements of limited or little wars." This was the advice of Air Force Secretary Donald A. Quarles, speaking at the recent annual

(*Continued on Page* 22)

## Duti-Rated Lifetime Gears

# REDUCE OVERHEAD CRANE DRIVE COST 30%


REDUCE OVERHEAD
30% REDUCE OVERH
CRANE DRIVE CO
RANE DRIVE C
COST 30% REDU
OST 30% RED
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T 30% REDUCE O
REDUCE OVERHEAD
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AD CRANE DRIVE C
VE COST 30% RED
30% REDUCE O
AMERICAN

Old gear train at left is large, cumbersome and inflexible. At right Foote Bros., designed gear train using Duti-Rated Gears—compact, light and efficient.

## 100% more capacity - 25% less weight - 28% less size

Ordinary commercial gearing in the traversing drive for an overhead, traveling crane system was bulky and had to be set at a space wasting 45° angle to save head room. Foote Bros. designed a special transmission system using Lifetime Duti-Rated Gears, permitting the application of smaller gears for the same capacity, allowing shorter center distances and a much more compactly designed drive.

The savings in space not only improved the design and performance of the overhead crane but also life expectancy. Maintenance requirements were greatly reduced. An outstanding feature of the new drive was that the Duti-Rated Gears could be interchanged on the same centers to change the ratios . . . allowing various speeds, fast and slow, for traversing.

This is only one example of what Duti-Rated Gears are doing in industry today. Extra gear capacity in less space . . . with longer life and lower costs . . . could be important to you, too. Call Foote Bros. today and learn all the advantages of Duti-Rated Lifetime Gearing . . . pre-engineered as standard or designed for your application. *FREE! Foote Bros. Engineering Manual "Duti-Rated Lifetime Gearing". Write for your copy today!*

**This trademark stands for the finest industrial gearing made!**

FOOTE BROS. Duti-Rated® LIFETIME GEARING

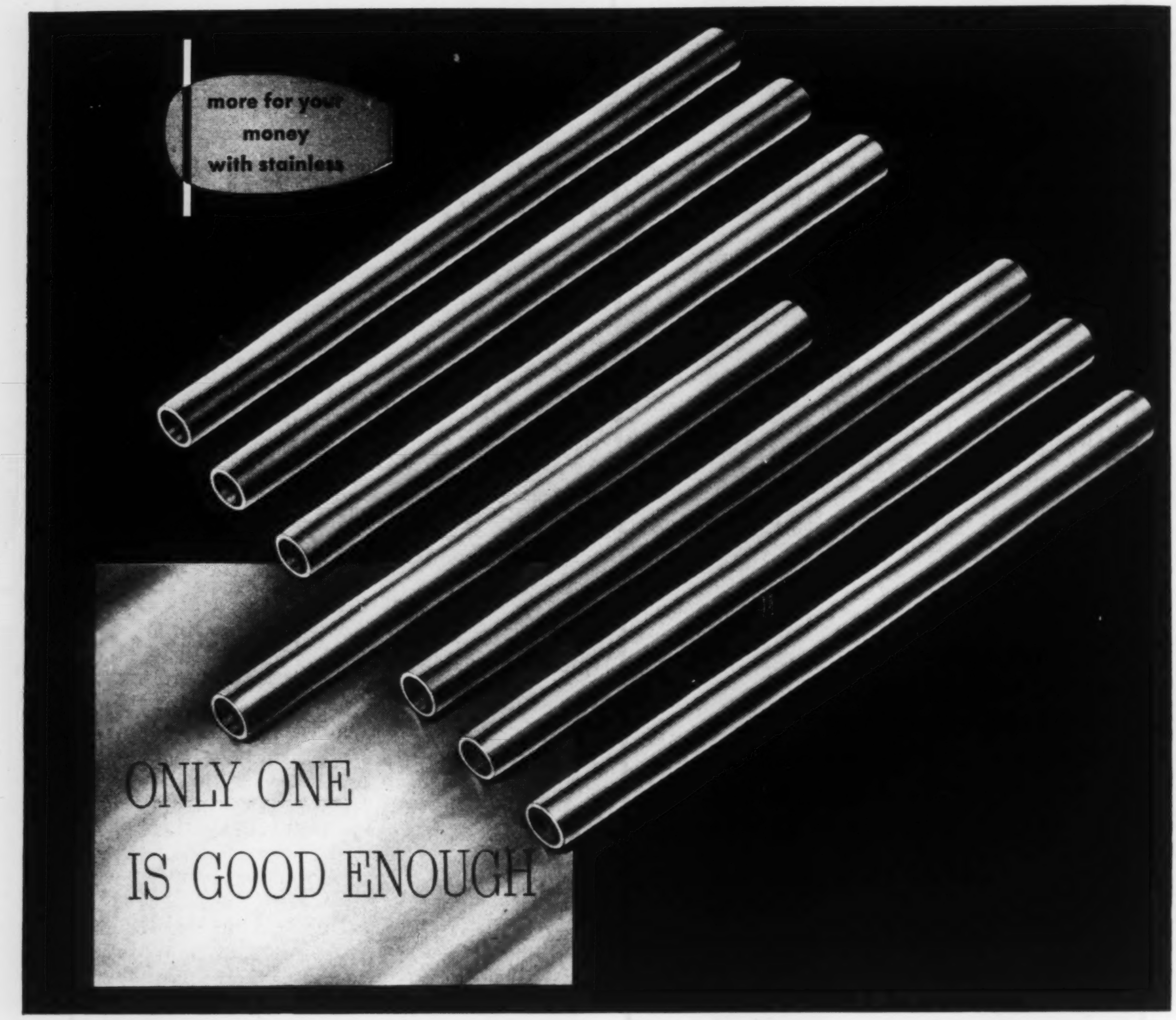
T.M. Reg. U.S. Pat. Off.

# FOOTE BROS.

*Better Power Transmission Through Better Gears*

**Foote Bros. Gear and Machine Corporation**
4545 South Western Blvd., Dept. O, Chicago 9, Ill.

*Circle 411 on page 19*



The best stainless tubing for a specific application cannot be identified by surface appearance alone. The answer is found in the grain structure. Because your guarantee of satisfactory service rests *inside* the metal, it is most important for the stainless tubing buyer to consider his supplier's methods of manufacture.

Corrosion resistance, which prevents product contamination, depends upon heat treatment. Heat treatment of stainless steel tubing for a specific end use may vary according to grade, size of tube and service requirements involved. For instance, the austenitic grades of stainless steel have optimum corrosion resistance only when all carbides have been dissolved and retained in solution by rapid cooling. At B&W, heat treatment is rigidly controlled, and every piece of stainless tubing is heat treated to provide optimum corrosion resistance when that property is required.

For virtually any application—pressure or mechanical—B&W can provide either seamless or welded stainless tubing in any number of grades, in a broad size range. Help is available through B&W Regional Sales Offices and a nationwide network of experienced tubing distributors. Mr. Tubes—your link to B&W—will be pleased to furnish detailed answers to your stainless tubing problems. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

**B&W**
**TUBULAR PRODUCTS DIVISION**

TA-6066-M

Seamless, welded tubular products, seamless welding fittings & forged steel flanges—in carbon, alloy & stainless steels

MACHINE DESIGN
READER SERVICE

# Reader Information Service

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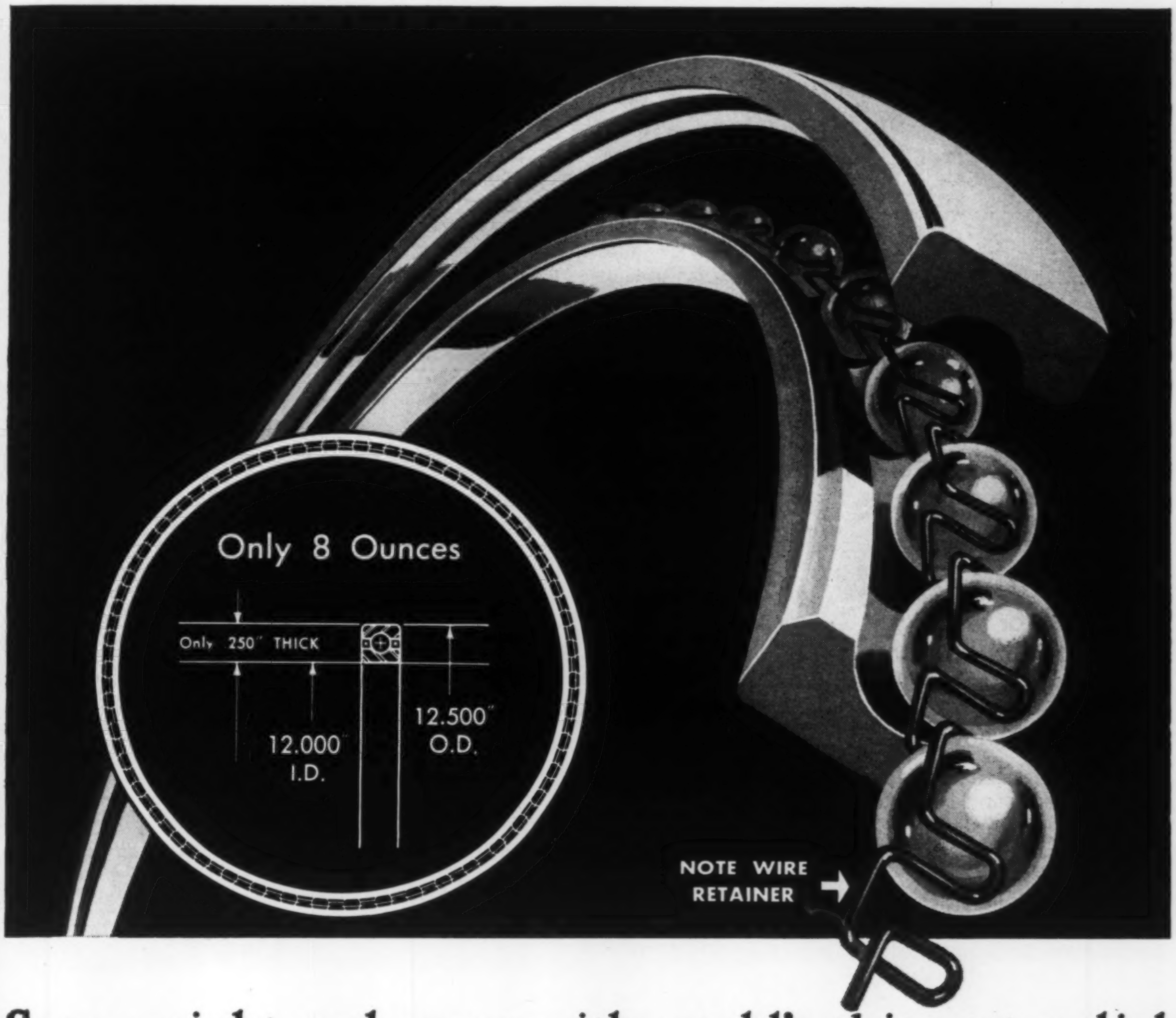


# Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

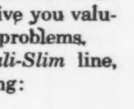
The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

*Reali-Slim Ball Bearings* — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

*Reali-Slim Roller Bearings* — Radial and taper roller types in cross sections from 9⁄16" and in bore diameters from 5" to 40".



**THE KAYDON ENGINEERING CORP.**

MUSKEGON • MICHIGAN

K-561

*All types of ball and roller bearings — 4" bore to 120" outside diameter . . .*

*Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Ball Radial • Ball Thrust Bearings*

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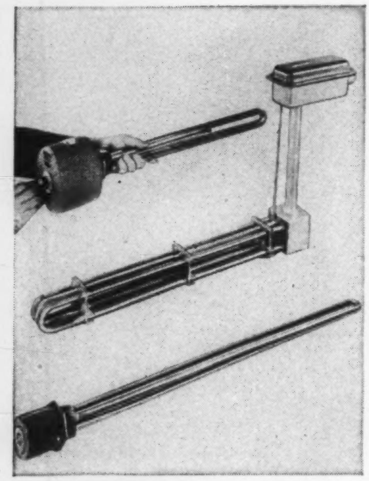

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**IMMERSION HEATERS**
with or without
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*... fit the heat to your need*
*up to 100,000 watts*
*and 2,500 psi*

Full range of sizes and ratings in portable, screw-plug and flanged types. Available with copper, steel or alloy sheaths to resist corrosion.

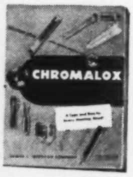
Used for heating water, asphalt, greases, molten salts, pickling and plating baths, process kettles; for superheating steam and compressed air; for melting lead, solder, babbit; and for a wide range of similar applications.

**Let the Chromalox Sales-Engineering staff solve your heating problems... electrically.**

**Write for your copy of Catalog 50**

—for full information on the complete line of Chromalox Electric Heaters and controls.

For ideas on additional applications of electric heat, request Booklet F1550—"101 Ways to Apply Electric Heat."



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*Circle 414 on page 19*

(*Continued from Page* 14)

meeting of the ASME. Secretary Quarles also told the engineers that design objectives in the increasingly complex weapons for atom-scale war must be reliability and maintainability. He said that keeping adequate numbers of competent maintenance technicians was as much a problem as keeping the quality lead in the weapons themselves.

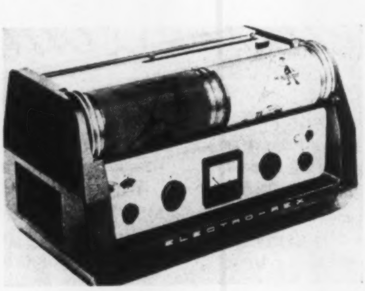
"Any thought," he said, "that under present conditions nations will rule out nuclear war, or any other kind of war, on moral grounds ignores the lessons of history, some of which are recent history. Such a delusion could result in undermining our retaliatory position to a point that might tempt an aggressor to strike us in the hope of achieving a quick and favorable decision."

The U.S. now has a clear margin of qualitative superiority over Communist military strength, thanks to "our very gratifying success in meeting high standards for people and hardware." He added, however, that the problem of qualitative superiority in operations people is not so clear-cut or so widely understood as the problem of maintaining an edge in weapons and equipment.

He urged engineers to help maintain a proper balance between operating skill and hardware by designing as much reliability as possible into new equipment and by making the equipment as simple as possible consistent with performance requirements.

He pointed out that the F-89 interceptor uses enough tubes or transistors for 80 home radios and that the B-47 contains a complex of 14 electronic systems.

"In this light," he said, "we begin to understand that achieving the full potential of modern weaponry depends not only on the scientist that lays the groundwork for it, and the engineer that designs it. It also depends finally and critically on the individual technician — on his skill, experience, and devotion to the job of keeping it in operation."



PHOTOS CAN BE COPIED on office duplicators, offset or mimeograph type, with stencils prepared on this new machine. An optical scanning system in the Electro-Rex stencil cutter converts images to high frequency current which is amplified electronically and transferred to the reproduction side of the drum. Scanning definition from 125 to 750 lines per in. is claimed attainable.

---

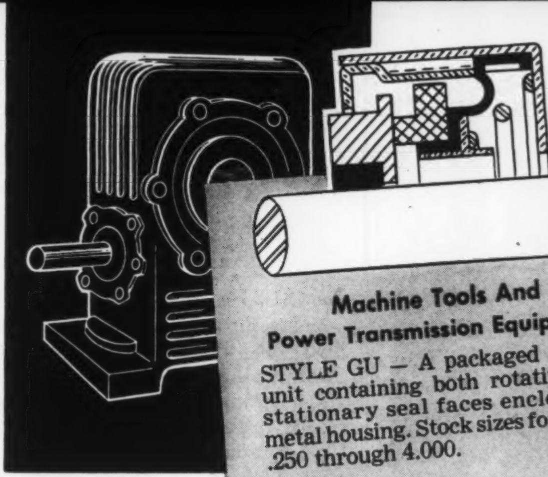
**Carbon tetrachloride users are warned** that they are handling a deadly poison, according to an article in the December *Readers Digest*. Vapors of $CCl_4$ attack the nervous system, kidneys, intestines and liver. Generous amounts of the material are used daily in drawing rooms to clean drafting tools.

## Meetings
### AND EXPOSITIONS

**Jan. 14-18—**
**Society of Automotive Engineers Inc.** Annual Meeting to be held at the Sheraton-Cadillac and Statler Hotels, Detroit. Further information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

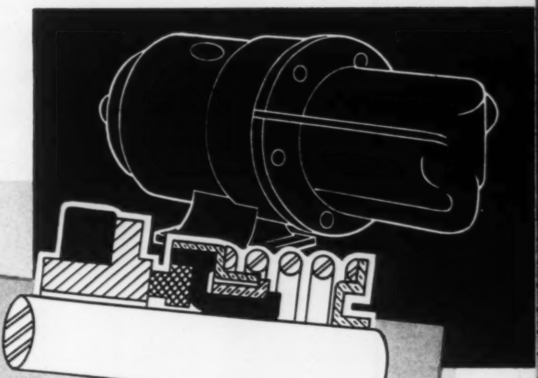
**Jan. 16-18—**
**Society of Plastics Engineers Inc.** Thirteenth Annual National Technical Conference to be held at the Hotel Sheraton-Jefferson, St. Louis. Further information can be obtained from society headquarters, 34 E. Putnam Ave., Greenwich, Conn.

**Jan. 17-18—**
**Engineers Joint Council** General Assembly to be held at the Statler



**Machine Tools And Power Transmission Equipment**

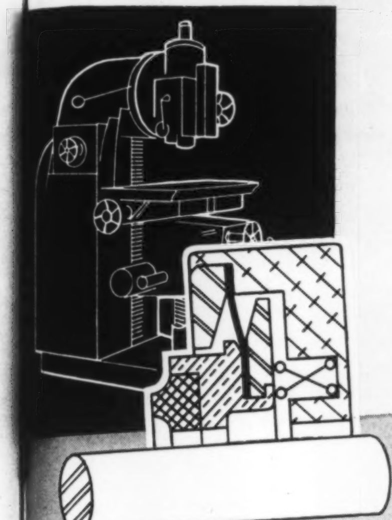
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



**Pumps And Compressors**

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



**Heavy Machine Tools**

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

A Complete Line

GITS SHAFT SEALS

For Every Application

**These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.**

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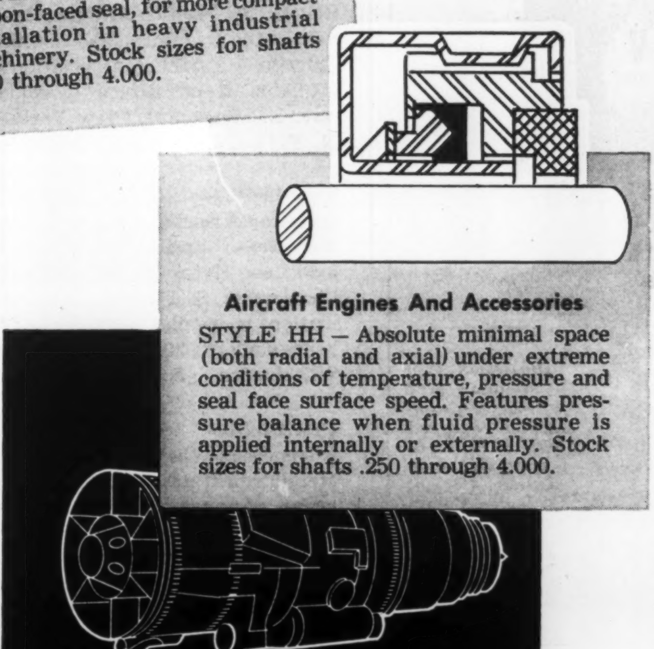
**Household Appliances**

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



**Aircraft Engines And Accessories**

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.

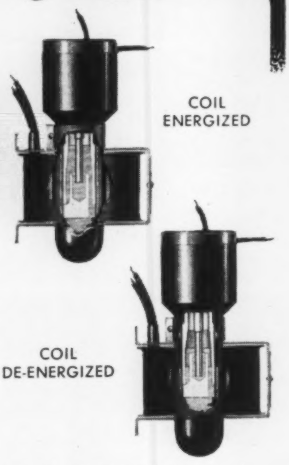
*Circle 415 on page 19*

The
TIMER RELAY
that eliminates
controlled timing
problems

1936 · 20th ANNIVERSARY · 1956
DURAKOOL

- ★ No false contacts
- ★ Non sticking
- ★ Practically "fail safe"
- ★ Low cost timer

Durakool
STEEL MERCURY TIMERS



This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Any combination of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.

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DURAKOOL, INC.
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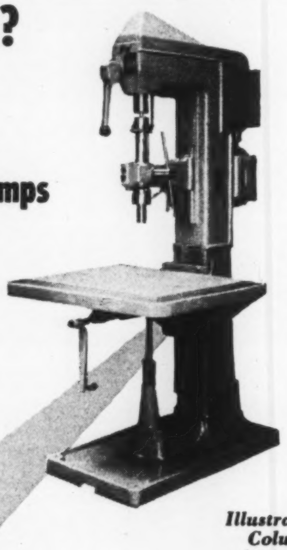
Send for Bulletin 800

Circle 416 on page 19

More Production?
Specify
RUTHMAN
GUSHER Coolant Pumps



Your Gusher Coolant Pump gives you instantaneous coolant flow the split second you turn on the machine. There is no priming necessary, chips cannot injure the pump. You're sure of a long trouble-free life . . . high production when you specify Gusher Coolant Pumps for your machinery. Write for our *New* Catalog.

*Illustrated is a Column type Avey Drilling Machine equipped with a 11020 B-Short Ruthman Gusher Coolant Pump.*

THE RUTHMAN MACHINERY CO.
1811 Reading Road
Cincinnati, Ohio

Circle 417 on page 19

Hotel, New York. Further information is available from council headquarters, 29 W. 39th St., New York 18, N. Y.

**Jan. 21-22—**
**Solar Furnace Symposium** to be held at Hotel Westward Ho, Phoenix, Ariz. Sponsors are the Association for Applied Solar Energy, Stanford Research Institute, Arizona State College and the University of Arizona. Further information can be obtained from Mr. John I. Yellott, 3424 N. Central Ave., Phoenix, Ariz.

**Jan. 21-25—**
**American Institute of Electrical Engineers.** Winter General Meeting to be held at the Hotel Statler, New York. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

**Jan. 28-31—**
**Plant Maintenance and Engineering Show** to be held at the Cleveland Public Auditorium. Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

**Feb. 5-7—**
**Society of the Plastics Industry Inc.** Twelfth Annual Technical and Management Conference of the Reinforced Plastics division, to be held at the Edgewater Beach Hotel, Chicago. Further information is available from society headquarters, 250 Park Ave., New York 17, N. Y.

**Feb. 15-16—**
**National Society of Professional Engineers.** Spring Meeting to be held at Hotel Francis Marion, Charleston, S. C. Further information is available from society headquarters, 2029 K St., N. W., Washington 6, D. C.

**Feb. 24-28—**
**American Institute of Mining, Metallurgical and Petroleum Engineers.** Annual Meeting to be held at the Hotel Jung, New Orleans. Additional information can be obtained from the institute's headquarters, 29 W. 39th St., New York 18, N. Y.

# MEN
## OF MACHINES

**Sidney L. Eastman** has been appointed vice president in charge of engineering by Cleveland Worm & Gear Co., Cleveland. Mr. Eastman joined the company as an engineer in the test laboratory in 1927. He next served as district manager in Detroit, then as assistant sales manager. In 1940 he was named assistant chief engineer. Mr. Eastman was promoted to chief engineer four years later and held that position at the time of his new appointment.

Sidney L. Eastman

The election of **Henry M. Haase** to vice president in charge of engineering and research has been announced by Borg-Warner Corp., Chicago. He will direct the firm's program of product planning and engineering research and development, including general supervision of the new Research Center in Des Plaines, Ill. and the Petro-Mechanical Research Div. in Los Angeles.

**William Alvarez** has been named manager of engineering for General Electric's Industry Control Dept., Roanoke, Va. Mr. Alvarez joined the company in 1940, completed the G-E test course, and

*Westinghouse pilot plant for precision castings speeds development, saves capital investment*

**Proving ground for castings**

Now . . . without heavy capital investment . . . you can prove your ideas and developmental work for molded metal products.

Modern pilot plant facilities are available at the new Westinghouse metals plant, Blairsville, Pa., to help you explore full production conditions and create prototype quantities. Here you can compare conveniently all types of castings at one place from the same heat.

Open production capacity is also available for fast, dependable delivery on precision investment castings (lost wax process), shell-mold castings and powder metal parts.

In making a value analysis of your product components, consider molded metal parts for pieces involving intricate shapes, close tolerances, difficult machining operations or component assemblies. You save machining, improve finishes, reduce rejections.

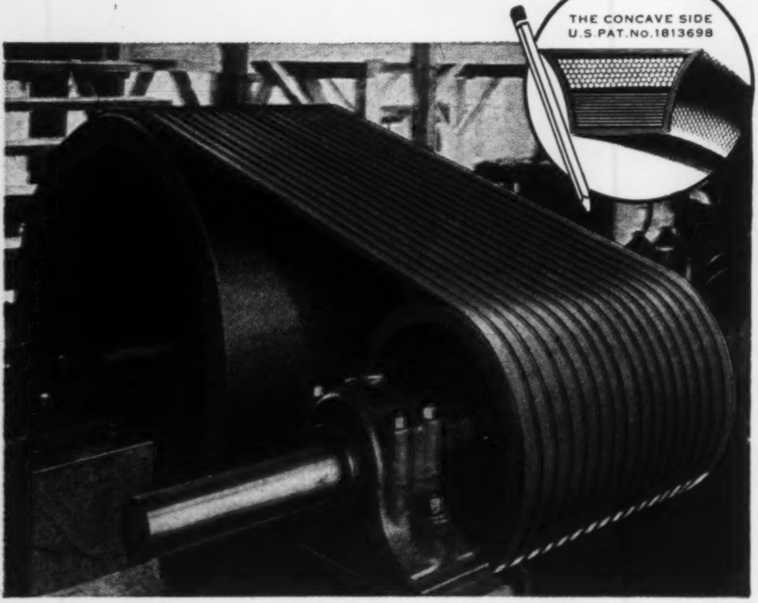
*Send today* for further details and a copy of DB 52-500. Also enclose a photo, drawing or sample of the part you want evaluated. No obligation. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-05001

**WATCH WESTINGHOUSE!**

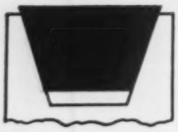
*WHERE **BIG** THINGS ARE HAPPENING **TODAY!***

Circle 418 on page 19

Why a V-Belt with CONCAVE SIDES wears longer



**It is easy to demonstrate to yourself why the concave sides (Fig. 1) of the Gates belt greatly lengthen belt life.**

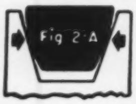


Simply bend a Gates belt and feel the sides. Notice how these precisely engineered concave sides *fill out* on the bend and *become straight*. Thus a Gates belt grips the sheave groove evenly (Fig. 1-A) and wear is distributed uniformly across each side of the belt. That means longer belt life; lower costs.

Make the same test with a straight-sided belt (Fig. 2) and see what happens. The sides bulge out on the bend (Fig. 2-A) concentrating the wear at points shown by arrows.

To assure longer wear and keep belt costs down, specify the V-belt with Concave sides—Gates Vulco Rope . . . readily available from nearby distributor stocks. The Gates Rubber Company, Denver, Colorado—*World's Largest Maker of V-Belts.*

Gates



*There are Gates Engineering Offices and Distributor Stocks in all industrial centers of the United States and Canada, and in 70 other countries throughout the world.*

TPA 90

Gates VULCO ROPE Drives

Circle 419 on page 19

## *Men of Machines*

was assigned to the engineering section of the Control Div. In 1952 he was appointed manager of advance engineering in the Industry Control Dept. Earlier this year he was named acting manager of engineering.

The Indiana Steel Products Co., Valparaiso, Ind., has announced the appointment of **James R. Ireland** as director of research and engineering. Mr. Ireland joined the firm as director of research in October, 1953. He was previously chief engineer of Thomas and Skinner Steel Products and an engineer in the Magnetic Materials Dept. of Western Electric Co. Mr. Ireland is the author of the article "Permanent Magnets," which appeared in the April, 1949 issue of MACHINE DESIGN.

James R. Ireland

**Donald C. Erdman** has been appointed assistant to the president of Sperry Products Inc., Danbury, Conn. Mr. Erdman was formerly president and chief engineer of Electro Circuits Inc.

Motorola Inc., Chicago, recently announced a number of new assignments. **Jack Davis,** former radio products manager, was named vice president for consumer products engineering. He is succeeded by **Fred Williams,** former home radio chief engineer. **Robert Trojan,** former project engineer for home radio, replaces Mr. Williams. **Henry Magnuski,** former chief engineer of the applied research department, was named staff scientist to the executive vice president. **Roy Olson,** previously director of engineering of the Microwave and Industrial Control Dept., is now manager of that department, and **Angus MacDonald** is director of engineering. He was assistant director of engineering of the C & E Div. **William Firestone,** former assistant chief engineer of the applied research department of the C & E Div., was named chief engineer. **William Weisz,** former product manager of portable products, is now chief engineer for two-way radio and portable products.

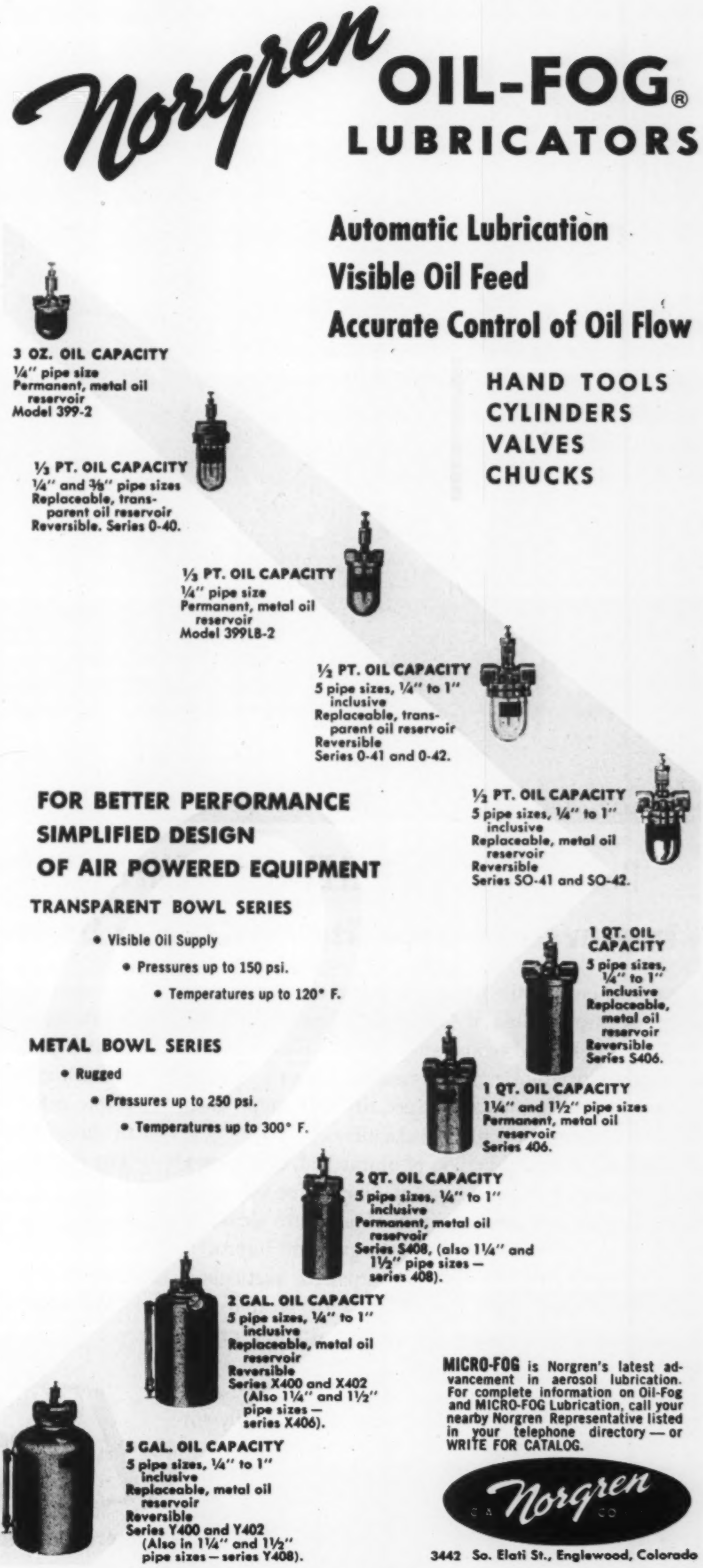
**W. H. Bennett** has been named president of the Hydraulic Press Mfg. Co., Mount Gilead, O., a division of Koehring Co. Mr. Bennett, who joined H-P-M in 1939, has held various positions in the company, including that of director of engineering.

The Semiconductor-Components division of Texas Instruments Inc., Dallas, Tex., has appointed **J. N. Carman** chief mechanical engineer. Mr. Carman was manager of the engineering department of Pacific Semiconductors Inc. Previously, he had been associated with Hughes Aircraft Co. and General Electric Co.

**Edward McClaud** has been appointed chief engineer in charge of product, process and tool engineering by Parker Stamp Works, Hartford, Conn. Mr. McClaud, who was formerly associated with Pratt & Whitney Aircraft, joined Parker last January.

**Richard J. Brown** has joined Crescent Metal Products Inc., Cleveland, as chief engineer. He was chief engineer at Perfection Industries Inc.

**Jack W. Qualman** has been appointed assistant chief engineer of the Detroit Transmission Div. of General Motors Corp., Ypsilanti, Mich. He will direct future product design and development.



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Visible Oil Feed
Accurate Control of Oil Flow

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CYLINDERS
VALVES
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3 OZ. OIL CAPACITY
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Permanent, metal oil reservoir
Model 399-2

⅓ PT. OIL CAPACITY
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Replaceable, transparent oil reservoir
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½ PT. OIL CAPACITY
5 pipe sizes, ¼" to 1" inclusive
Replaceable, transparent oil reservoir
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Series 0-41 and 0-42.

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5 pipe sizes, ¼" to 1" inclusive
Replaceable, metal oil reservoir
Reversible
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FOR BETTER PERFORMANCE
SIMPLIFIED DESIGN
OF AIR POWERED EQUIPMENT

TRANSPARENT BOWL SERIES
- Visible Oil Supply
- Pressures up to 150 psi.
- Temperatures up to 120° F.

METAL BOWL SERIES
- Rugged
- Pressures up to 250 psi.
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1 QT. OIL CAPACITY
5 pipe sizes, ¼" to 1" inclusive
Replaceable, metal oil reservoir
Reversible
Series S406.

1 QT. OIL CAPACITY
1¼" and 1½" pipe sizes
Permanent, metal oil reservoir
Series 406.

2 QT. OIL CAPACITY
5 pipe sizes, ¼" to 1" inclusive
Permanent, metal oil reservoir
Series S408, (also 1¼" and 1½" pipe sizes — series 408).

2 GAL. OIL CAPACITY
5 pipe sizes, ¼" to 1" inclusive
Replaceable, metal oil reservoir
Reversible
Series X400 and X402 (Also 1¼" and 1½" pipe sizes — series X406).

5 GAL. OIL CAPACITY
5 pipe sizes, ¼" to 1" inclusive
Replaceable, metal oil reservoir
Reversible
Series Y400 and Y402 (Also in 1¼" and 1½" pipe sizes — series Y408).

MICRO-FOG is Norgren's latest advancement in aerosol lubrication. For complete information on Oil-Fog and MICRO-FOG Lubrication, call your nearby Norgren Representative listed in your telephone directory — or WRITE FOR CATALOG.

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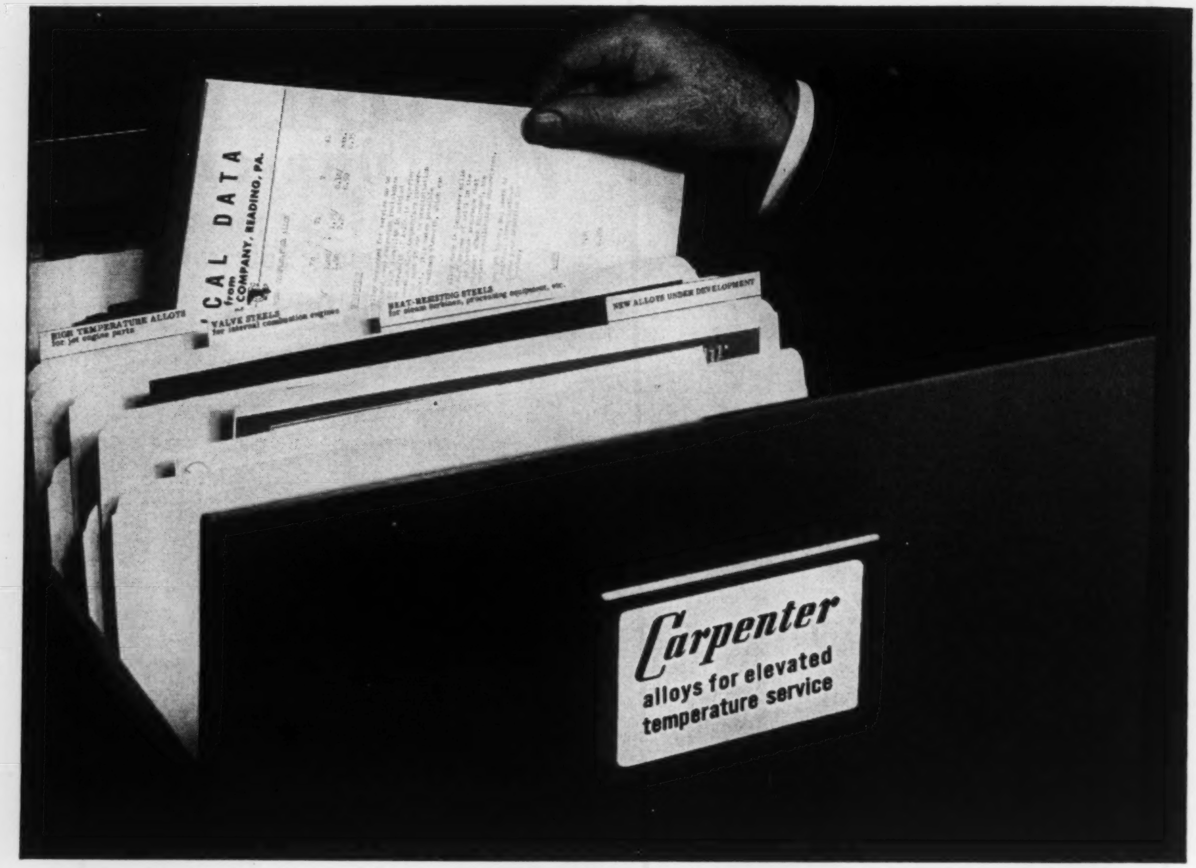
*Circle 420 on page 19*


CAL DATA
from
COMPANY, READING, PA.
HIGH TEMPERATURE ALLOYS
for jet engine parts
VALVE STEELS
for internal combustion engines
HEAT-RESISTING STEELS
for steam turbines, processing equipment, etc.
NEW ALLOYS UNDER DEVELOPMENT
Carpenter
alloys for elevated temperature service

## Discover how these ELEVATED TEMPERATURE ALLOYS can give you

**√ Improved Forgeability √ Greater Uniformity √ Cleaner Steels**

Exciting possibilities for improvement are ahead when you look into the line of Carpenter alloys for parts or products in elevated temperature service. Here is a line of high temperature and heat-resisting alloys produced in a *specialty* mill. Only a true specialty mill can produce so well these very difficult-to-make alloys.

Here, too, is a combination of unusual advantages not normally found in this type of alloys. For example, Carpenter pioneered the addition of rare earth elements to the analyses of certain grades to give you improved forgeability. And Carpenter's unsurpassed, meticulous quality controls, assure you steels with greater uniformity and extra cleanness to meet the strictest inspection requirements.

Whether you work with one of our present elevated temperature alloys, or a steel produced specifically for your own application, you'll find that Carpenter's wealth of fabricating and working information will help you substantially reduce production costs and get better parts.

Outline your plans or problems to your Carpenter Representative or write direct. You'll get the kind of help that pays off with definite improvements. *The Carpenter Steel Co., 120 W. Bern St., Reading, Pa.*

**Specify Carpenter alloys for elevated temperature service and get these three big advantages . . .**

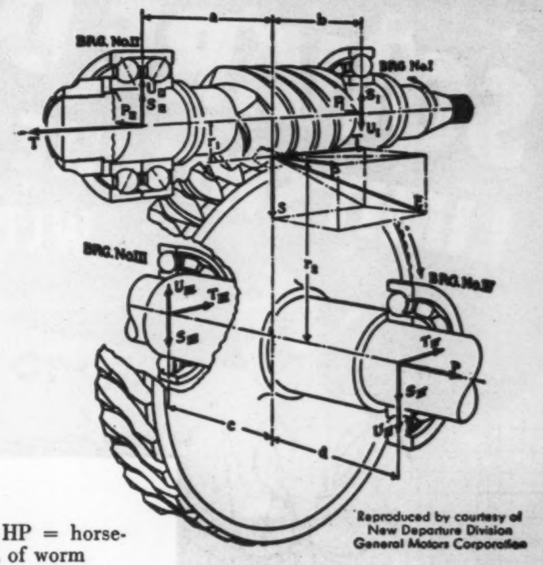
Improved Forgeability
Greater Uniformity
Cleaner Steel

**Carpenter STEEL**

**Improved Alloys for Elevated Temperature Service**

## Helpful Data from DE LAVAL

# How to Calculate Worm Gear Bearing Loads



Reproduced by courtesy of New Departure Division General Motors Corporation

$Q = \frac{HP \times 63025}{N}$ = TORQUE INPUT to worm, lbs. inches; HP = horsepower transmitted and N = rev. per min. of worm

$P = \frac{Q}{r_1}$ = TANGENTIAL FORCE of worm, where

$r_1$ = Pitch radius of worm in inches
[$r_2$ = Pitch radius of worm gear
$= \frac{1}{2\pi}$ (number of teeth in gear x axial worm pitch)]

$S = \frac{P \tan \alpha}{\tan \gamma}$ = SEPARATING FORCE, where
$\alpha$ = Axial tooth pressure angle*
$\gamma$ = Helix or lead angle of worm*
$= \tan^{-1} \frac{\text{lead}}{2\pi r_1}$, or $\tan^{-1} \frac{\text{Number of threads x axial worm pitch}}{2\pi r_1}$

$T = \frac{P}{\tan \gamma}$ = WORM THRUST, or tangent force driving worm gear

* LEAD ANGLE 0°-35° use 27½° Pressure Angle
LEAD ANGLE 35°-45° use 30° Pressure Angle

### BEARING LOADS

| Due to | on Brg. I | on Brg. II |
|---|---|---|
| P | $P \frac{a}{a+b} = P_I$ | $P \frac{b}{a+b} = P_{II}$ |
| S | $S \frac{a}{a+b} = S_I$ | $S \frac{b}{a+b} = S_{II}$ |
| T | $T \frac{r_1}{a+b} = U_I$ | $T \frac{r_1}{a+b} = U_{II} = U_I$ |
| Total Rad. Load | $\sqrt{P_I^2 + (S_I - U_I)^2}$ | $\sqrt{P_{II}^2 + (S_{II} + U_{II})^2} = R_{II}$ |
| Thrust Load | | T |
| Total Load | $\sqrt{P_I^2 + (S_I - U_I)^2}$ | $\sqrt{R_{II}^2 + T^2}$ |

| Due to | on Brg. III | on Brg. IV |
|---|---|---|
| P | $P \frac{r_2}{c+d} = U_{III}$ | $P \frac{r_2}{c+d} = U_{IV} = U_{III}$ |
| S | $S \frac{d}{c+d} = S_{III}$ | $S \frac{c}{c+d} = S_{IV}$ |
| T | $T \frac{d}{c+d} = T_{III}$ | $T \frac{c}{c+d} = T_{IV}$ |
| Total Rad. Load | $\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$ | $\sqrt{T_{IV}^2 + (S_{IV} + U_{IV})^2} = R_{IV}$ |
| Thrust Load | | P |
| Total Load | $\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$ | $\sqrt{R_{IV}^2 + P^2}$ |

**Speed Change**

$$\text{Gear rpm} = N \times \frac{\text{Number of threads in worm}}{\text{Number of teeth in gear}}$$

**For simplicity in bearing load computations for worm gearing, the normal tooth force E is treated in terms of its three perpendicular elements, namely, P, the tangential driving force at pitch radius of worm; S, the force tending to separate worm from the gear, due to the pressure angle; and T, the thrust produced by the lead or helix angle of the worm.**

**If you have a problem in the selection or application of worm gearing, De Laval engineers will be glad to put their experience to work for you. Either write us giving complete details, or consult your local De Laval representative.**

**De Laval Steam Turbine Company,
858 Nottingham Way,
Trenton 2, New Jersey**

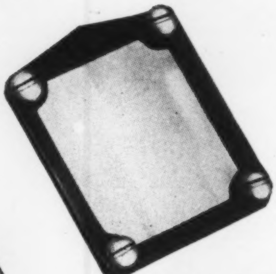
# SQUARE D LIMIT SWITCHES WITH -Features

## –TO THOSE WHO BUILD MACHINES

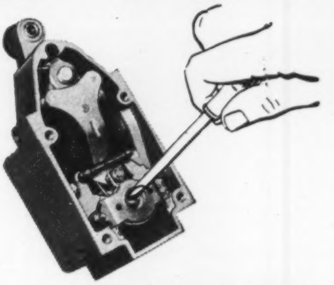
Square D limit switches have certain design features that warm the cockles of any machine builder's heart. You can spot the major ones in the panels below. Equally important is the customer's nod of approval when he sees the time-proven D nameplate on the limit switches that help control his new machine.

CLASS 9007
LIMIT SWITCH
RATING-AMPS
VOLTS A.C. D.C.
125 25 5.0
250 15 1.0
600 15 0.2
SQUARE D COMPANY
MILWAUKEE WIS. MADE IN U.S.A.

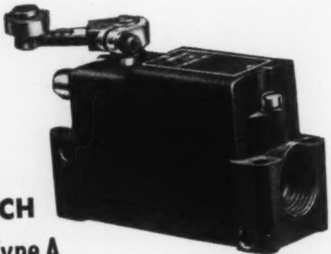
**HEAVY DUTY**
**OIL-TIGHT LIMIT SWITCH**
Class 9007 • Type T



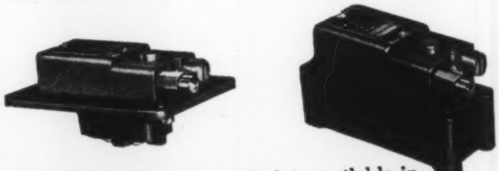
**Instant visual inspection of mechanism** through transparent plastic cover (optional). A tremendous time saver in multiple switch installations.



**Eleven contact arrangements** in one switch...and all you need to make the changes is a screwdriver!



SMALL
**OIL-TIGHT LIMIT SWITCH**
Class 9007 • Type A



**This small precision limit switch** is available in three forms — basic contact mechanism, flush mounting and surface mounting. Both flush and surface mounting switches are available with varying lengths of roller arms and with rollers of different types and sizes. Also push rod operated *(shown above)* and in single unit or duplex construction.

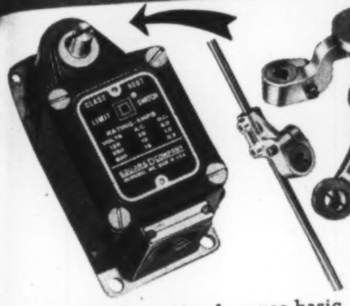
*NOW...***EC&M** PRODUCTS ARE A PART OF THE SQUARE D LINE!

**SQUARE D COMPANY**

# that Mean Plenty

## ...AND TO THOSE WHO BUY THEM

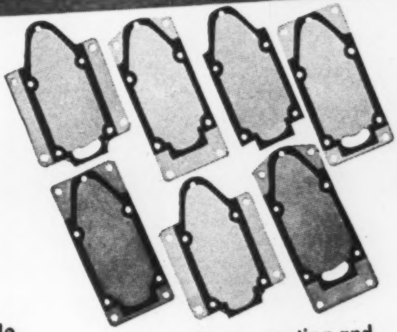
Just as you'd suspect, it's Square D's consistent performance and long life that appeals most to the men who buy and maintain the machines. But there are other advantages, too, having to do with versatility, easier installation and simpler maintenance. Some of the more important ones are illustrated below.



**Simplified stocking** because basic switches and a wide variety of lever arms are packaged separately. Moderate stock handles a multitude of combinations.

80°
OVERTRAVEL

**Continuously adjustable** operating lever arms permit an infinite number of adjustments! Up to 80° overtravel reduces arm breakage.



**Easy mounting and interchangeability** through wide variety of base plates and side mounting holes.

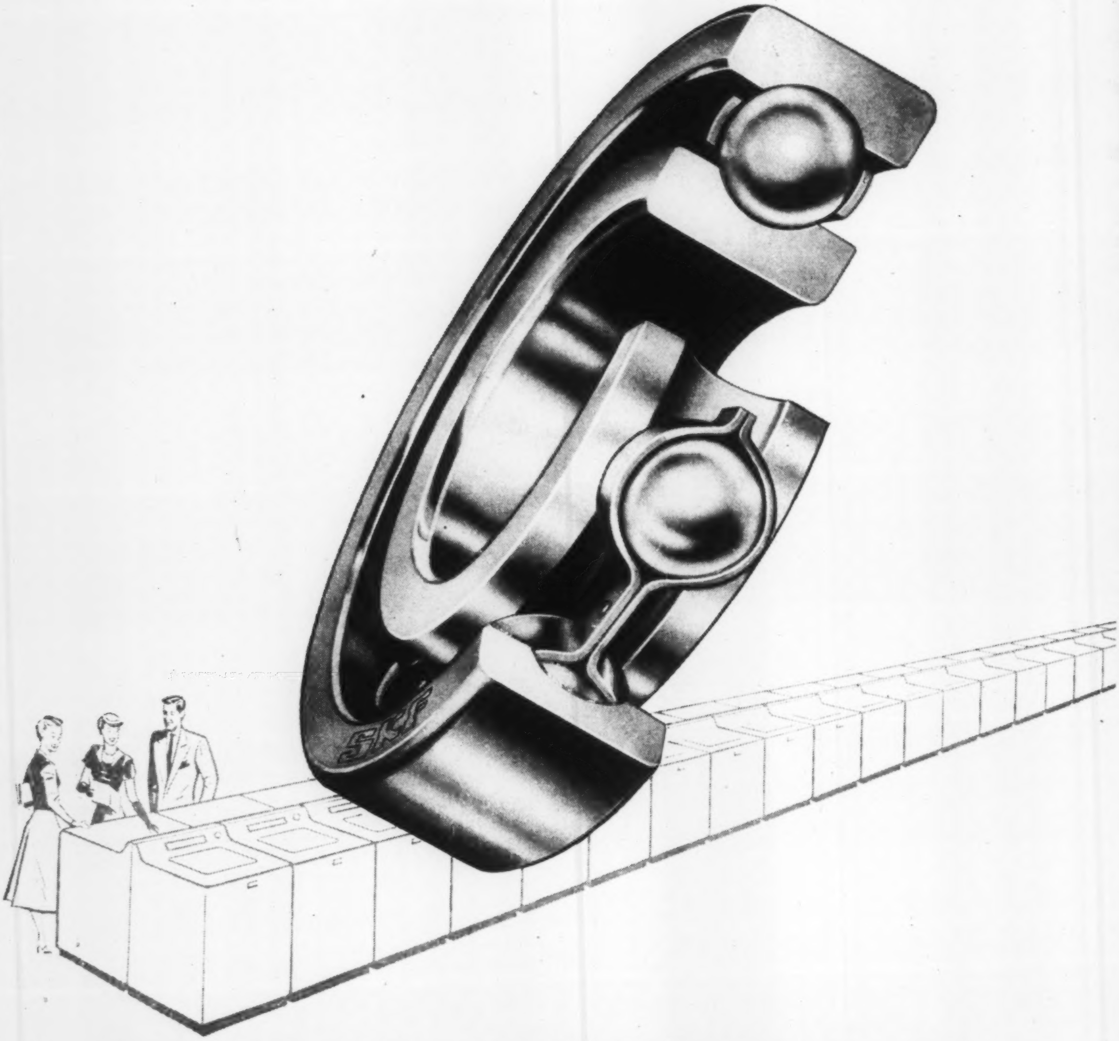
**Roller arms** are available in a wide range of designs and lengths.

***Write* for Bulletin 9007**

*. . . which gives the details of Square D's complete line of oil-tight limit switches. Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.*

*Everybody's Ahead with Square D!*

Circle 422 on page 19



# Quiet, smooth, perfect performance...

## in home laundry equipment using SKF* ball bearings

Leading manufacturers of home laundry equipment (names on request) rely on SKF Single Row, Deep Groove Ball Bearings for quiet, smooth-running performance.

Whatever your product, it will pay you, too, to switch to SKF anti-friction bearings and get the *plus values* which are built into every one. 7730

**SKF—EVERY TYPE—EVERY USE**

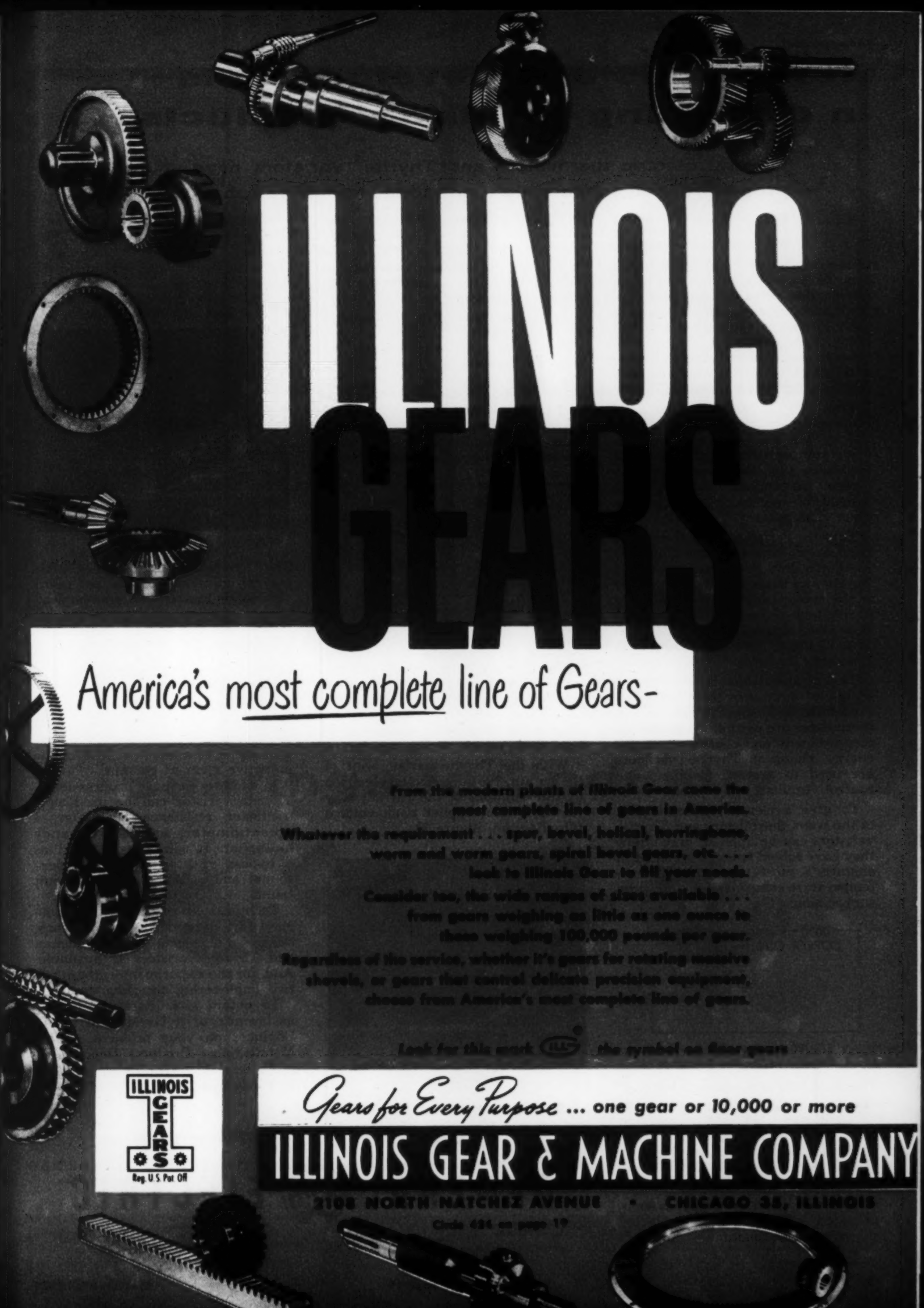
**SKF**

- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings* ("Tyson")

*Reg. U.S. Pat. Off.
Tyson Bearing Corporation

**SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.**

*Circle 423 on page 19*



ILLINOIS GEARS

America's most complete line of Gears-

From the modern plants of Illinois Gear come the most complete line of gears in America.

Whatever the requirement . . . spur, bevel, helical, herringbone, worm and worm gears, spiral bevel gears, etc. . . . look to Illinois Gear to fill your needs.

Consider too, the wide ranges of sizes available . . . from gears weighing as little as one ounce to those weighing 100,000 pounds per gear.

Regardless of the service, whether it's gears for rotating massive shovels, or gears that control delicate precision equipment, choose from America's most complete line of gears.

Look for this mark ILLG® the symbol on finer gears

ILLINOIS GEARS Reg. U.S. Pat. Off.

*Gears for Every Purpose* ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

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Circle 424 on page 19

***(Advertisement)***

# New trends and developments in designing electrical products . . .

## General Electric thermistors and Thyrite* varistors have unique properties that apparently contradict normal electrical laws. Here's how they can be harnessed to improve your product.

General Electric thermistors and Thyrite varistors are ceramic-like semiconductor resistance materials. Each has unique properties – apparently disobedient to normal physical laws – that enable it to perform tasks in electrical and electronic circuits which otherwise would require costly, complex components.

The distinguishing feature of thermistors is their *thermal* sensitivity. Thermistors have large *negative* temperature coefficients of resistance (i.e., their resistance decreases tremendously when heated, instead of increasing slightly like other materials).

Thyrite varistors, on the other hand, are *voltage*-sensitive. Contrary to Ohm's law, a current through a Thyrite varistor varies as a *power* of the applied voltage (i.e., doubling the voltage through a Thyrite varistor can increase the current from 15 to 25 times, instead of the normal 2 times).

The applications based on the unique properties of these materials are almost limitless. In general terms, thermistors are used in the detection, measurement, and control of minute energy changes; Thyrite varistors are used to protect, stabilize, and control circuits.

To give a clearer understanding of the ways thermistors and Thyrite varistors can be applied, here's how they have solved two of the electrical engineer's most vexing problems – temperature compensation and surge suppression.

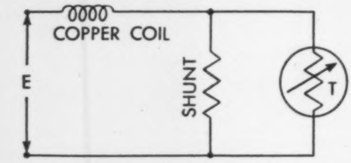

**FIGURE 1 — Typical thermistor temperature-compensation circuit**

The resistance of a conventional conductor is so affected by ambient temperatures that steady current flow cannot be maintained. For example, as the temperature of copper swings from −60° C to +80° C, the resistance increases 53%.

However, when the copper is compensated with a properly selected thermistor, the maximum deviation from the total average resistance at 25° C is only 3½% – despite the 140° swing in temperature.

In the circuit in Fig. 1, the thermistor's negative temperature coefficient of resistance offsets the positive temperature coefficient of the copper to stabilize current flow. In other circuits, thermistors can be utilized for signal and warning devices, sequence switching, and other time delay applications, because of the inherent thermal inertia involved.

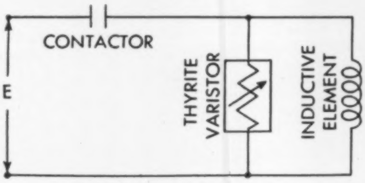

**FIGURE 2 — Thyrite varistor surge voltage suppression circuit**

Sudden interruptions of inductive circuits cause surge over-voltage, arcing, and high-frequency oscillations – all of which can cause trouble. The circuit in Figure 2 shows how a Thyrite varistor can be connected to hold these effects within safe limits.

With the Thyrite varistor out of the circuit, the surge voltage caused by interruptions of the current may rise to 9 times applied peak voltage (Oscillogram, Figure 3).

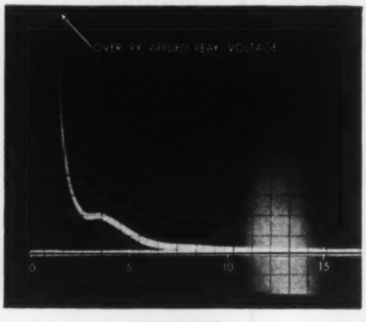

**FIGURE 3**

But with the Thyrite varistor in the circuit, (Figure 4), the surge voltage is limited to less than 3 times the normal applied peak voltage.

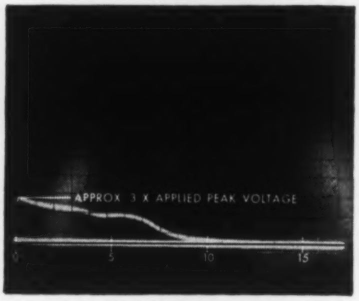

**FIGURE 4**

The Thyrite varistor draws negligible current at rated voltage, yet offers sufficiently low resistance at the peak current to limit the surge voltage to a safe value and to reduce arcing. Also, the Thyrite varistor quickly discharges circuit energy by providing increasingly higher resistance as the inductive current decays.

If a linear resistor were used to provide the same voltage suppression level, it would have to draw a current equal to more than 30% of the inductive element current.

In addition to surge suppression, a Thyrite varistor can be used as a nonlinear resistance parameter, a potentiometer, and a frequency multiplier. It can also be used as a bypass resistor to protect personnel and equipment from circuit faults.

Technical literature giving complete data on properties, applications, sizes, and shapes of G-E thermistors and Thyrite varistors is available. And, for the experimenter, there are two engineering test kits on each.

To obtain kits, literature, or the assistance of a General Electric Engineer on your problem, write: *Metallurgical Products Department of General Electric Company, 11126 E. 8 Mile Street, Detroit 32, Michigan.*

*Progress Is Our Most Important Product*

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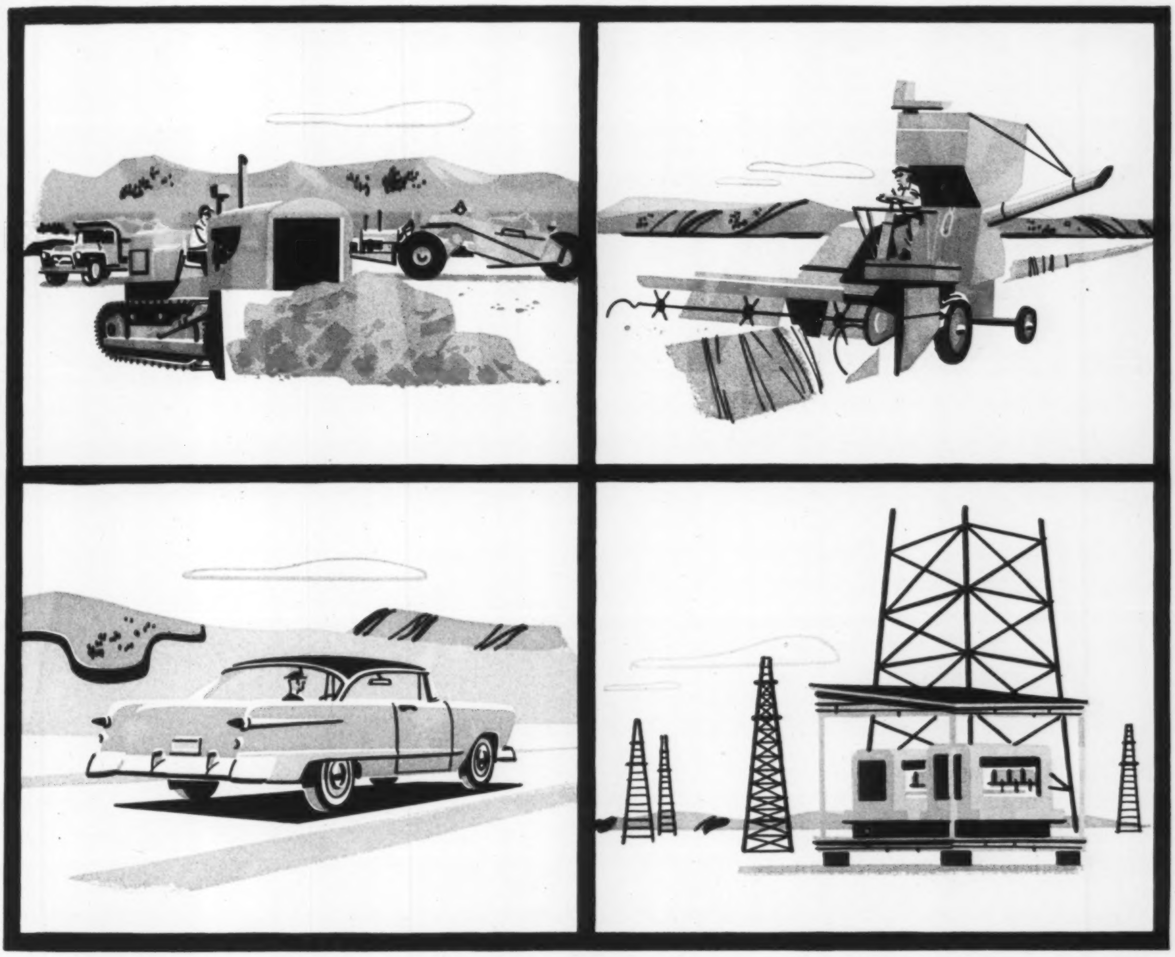
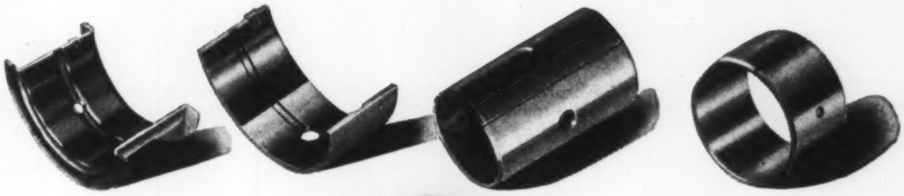


Bearings for industry



FEDERAL Mogul
SINCE 1899

FEDERAL-MOGUL DIVISION
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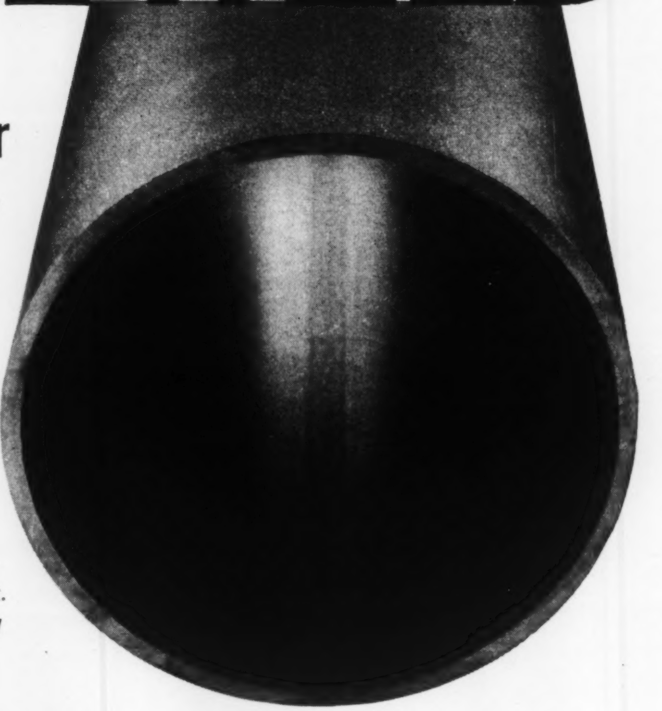
RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

# CONTOUR-TRENTWELD

## welded stainless pipe that's smoother, stronger

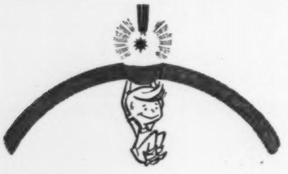


**New Contour-Trentweld outperforms any other pipe, welded or not.** Here's why: *Contour-Welding* is an entirely unique method of producing pipe and tubing. It puts gravity to work to pull down the molten weld metal until it exactly conforms to the contour of the pipe. Result: A smooth pipe or tube free of undercut or bead.

What's more, the *Contour-Weld* process *starts* with uniformly rolled stainless strip, which insures constant wall thickness throughout the pipe.

But the only way you can fully appreciate the advantages of new *Contour-Trentweld* is to try it. We think you'll agree, *it can't be beat by any other pipe, welded or not.*

### Why Trent's Exclusive Contour-Welding Process Means Smoother Welds . . .



Normally, in producing welded pipe, the weld is made at the top. But gravity plays a nasty trick. It tugs at the fluid metal in the weld zone, pulling it down toward the middle of the pipe. The result, particularly in the heavier gages, is a perceptible bulge where it hurts the most — right on the I.D. surface. If you try to get rid of the bulge — at fair cost — the metal is undercut — and corrosion and erosion start there.

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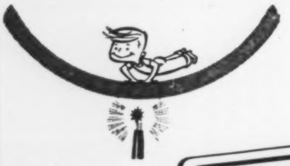


But Trent put a stop to that — simply by going into partnership with gravity. With their exclusive *Contour-Welding* process, they weld at the bottom — and gravity works for them. For then, the bulge is in the opposite direction — blending in perfectly with the contour of the pipe itself.

**CONTOUR TRENTWELD**

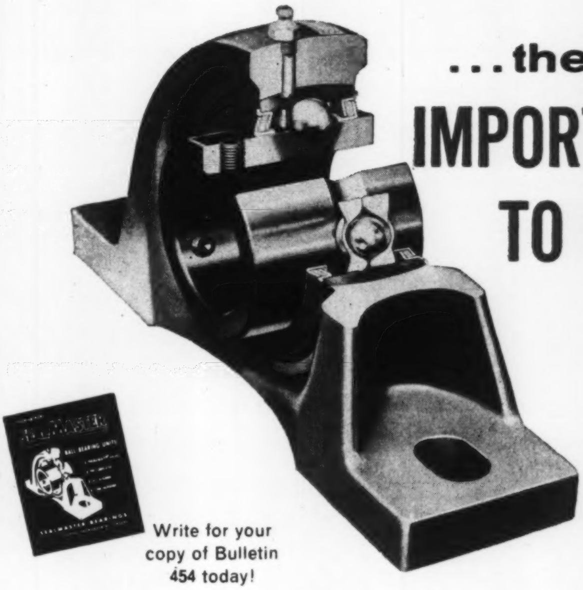
**Stainless and High Alloy Welded Tubing**

**TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of Crucible Steel Company of America)**

## This combination of features is EXCLUSIVE with . . .

# SEALMASTER

## BALL BEARING UNITS



## . . . they are IMPORTANT TO YOU!

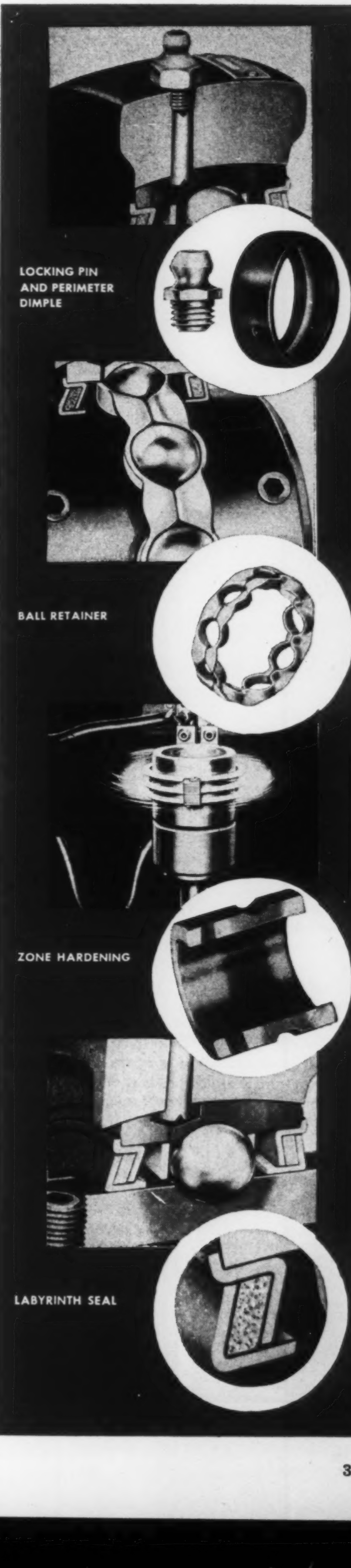
Write for your copy of Bulletin 454 today!

The products you design today to meet the demands of tomorrow must be carefully engineered right down to the smallest component. The product must be geared to the demands of an "automation minded" world and the competition of the years ahead. Production schedules can't be kept up when machinery is down for maintenance. No component you can build into your products will mean more to its efficient performance than the bearing units carrying the load. The exclusive combination of features found only in SEALMASTER self-aligning, pre-lubricated Bearing Units are important to your product's continuous performance and acceptance.

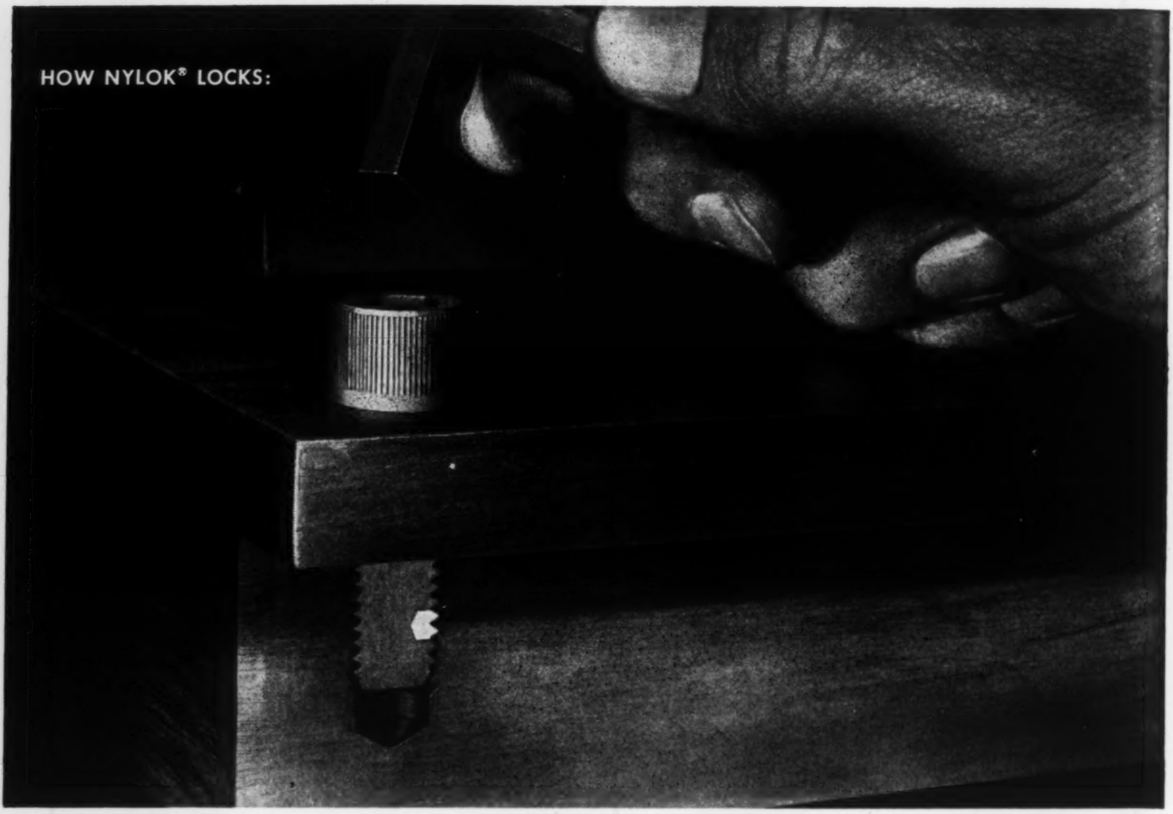
SEALMASTER
BALL BEARING UNITS

## SEALMASTER BEARINGS

A DIVISION OF STEPHENS-ADAMSON MFG. CO., 18 RIDGEWAY AVE., AURORA, ILLINOIS


LOCKING PIN AND PERIMETER DIMPLE
BALL RETAINER
ZONE HARDENING
LABYRINTH SEAL

*Circle 428 on page 19*



**LOCKED!** The tough, resilient nylon pellet keys itself into the mating threads. It forces threads together, and locks the screw securely.

# NEW—a complete line of self-locking UNBRAKO socket screw products that won't work loose

## They simplify design and save production time

UNBRAKO socket screws are now available embodying the Nylok* self-locking principle. Nylok provides a truly practical new solution to the problem of making screws self-locking.

You save production time when you build products with self-locking UNBRAKOS. And you get greater simplicity in design with less bulk and weight. The number of parts you must assemble to achieve full locking action is reduced to the absolute minimum. Lockwashers under screw heads are no longer necessary. Costly wiring of cross drilled heads is eliminated. So are cotter pins and complex multiple set screw installations.

Self-Locking UNBRAKOS are completely reusable. They have uniform locking and installation torques—with no galling or seizing on mating threads. They successfully withstand temperatures from —70° to 250°F. And, on properly seated screws, the pellet acts as a liquid seal.

Self-locking UNBRAKO socket screws come in a complete range of standard sizes and materials. See your authorized industrial distributor. Technical data and specifications are detailed in Bulletin 2193. Write us for your copy today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

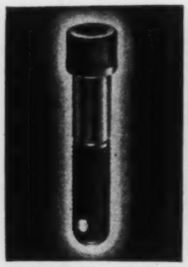
**T.M. Reg. U.S. Pat. Off., The Nylok Corporation*

**UNBRAKO SOCKET SCREW DIVISION**

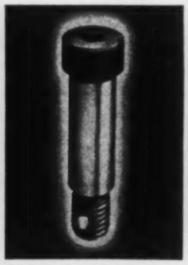
**STANDARD PRESSED STEEL CO.**

**SPS**

**JENKINTOWN PENNSYLVANIA**

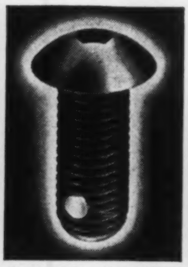


**Socket head cap screws.** Standard sizes #6 to 1 in.

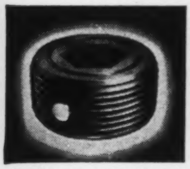


**Socket shoulder screws.** Standard sizes ¼ to ¾ in.

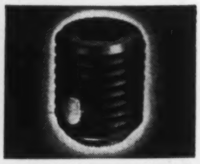
**Flat head socket screws.** Standard sizes #6 to ¾ in.



**Button head socket screws.** #6 to ⅝ in.



**Socket pressure plugs.** Standard sizes 1/16 to 1¼ in.

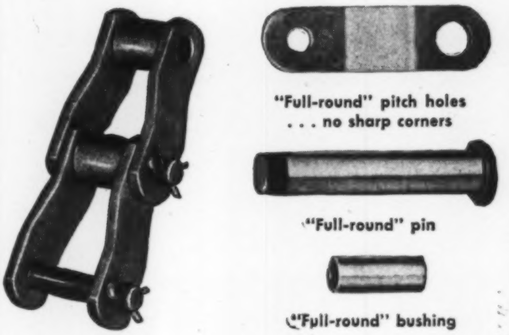


**Socket set screws.** All standard point types. #6 to 1 in.

Circle 429 on page 19

# "Stress raisers" eliminated by Link-Belt LXS chain design

## LXS "FULL-ROUND" DESIGN


"Full-round" pitch holes . . . no sharp corners
"Full-round" pin
"Full-round" bushing

**"FULL-ROUND" DESIGN** eliminates stress concentration points. Heat treatment of all parts adds even greater strength and extra wear life to selected steels. Accurate control of these processes avoids brittleness, poor wear values and low tensile strengths . . . and assures uniformity.

## Large pins, bushings mean ample live bearing area for long life

For long life under severe conveyor and drive conditions, Link-Belt LXS chain provides extra strength, increased wear resistance and wider application flexibility. This fabricated steel roller chain incorporates many advanced design and manufacturing refinements, resulting in superior ruggedness and accuracy.

### Eliminate weak points

"Full-round" design does away with stress concentration points most frequently subject to failure . . . provides maximum live bearing area between pin, bushing and sidebars. As a result, stress is distributed evenly, increasing chain life.

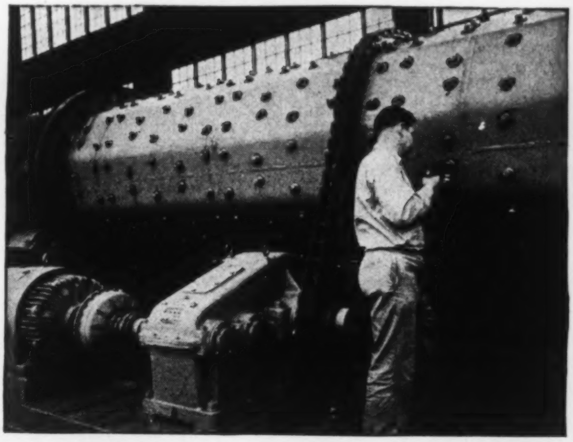
Pins and bushings are accurately sized for controlled press fit, preventing rotation in sidebars. Made from selected bar steel, sidebars are carefully machined for proper pitch hole size and for maintaining firm, tight press fit of pins and bushings. This assures close control of pitch and proper chain length after assembly.

### Hardening extends life

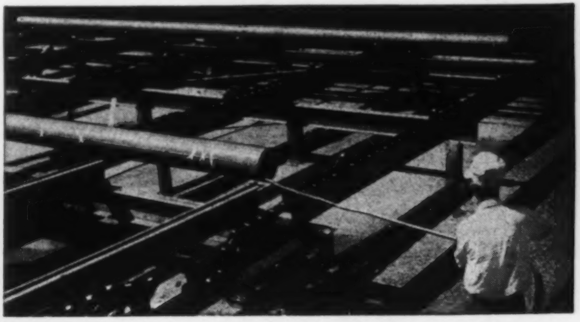
Another Link-Belt long-life extra is the controlled hardening of selected steels used in the manufacture of LXS chain. Pins, for example, are made from a tough steel, specially treated for high strength in shear and for maximum wear value. Bushings are properly hardened to shrug off shock and resist wear.

Rollers are accurately machined to assure proper operating clearances and free-rolling action. Controlled hardening gives them the necessary resiliency and durability.

## LXS especially popular for exposed drives, high impacts



Link-Belt LXS chain is the long-life answer for exposed drives, abrasive and high-impact conditions. Its large, live bearing area reduces cutting action of abrasives because load is spread over a broad area.



## LXS chain provides extra strength, wear-life for heavy-duty conveying

Link-Belt LXS chain has real stamina—as shown in this conveyor application for handling 1000-pound, 40-foot lengths of steel pipe. Thanks to accuracy of pitch and attachment spacing, plus close matching of multiple strands, LXS has the added strength and wear life for the extra-long conveyors so popular in today's move to mechanization.

For help with any chain problem call your nearby Link-Belt office. Send for 342-page catalog 950 covering the complete line of standard Link-Belt products for conveying and power transmission.

LINK-BELT
CATALOG
950

**LINK-BELT**

**CHAINS AND SPROCKETS**

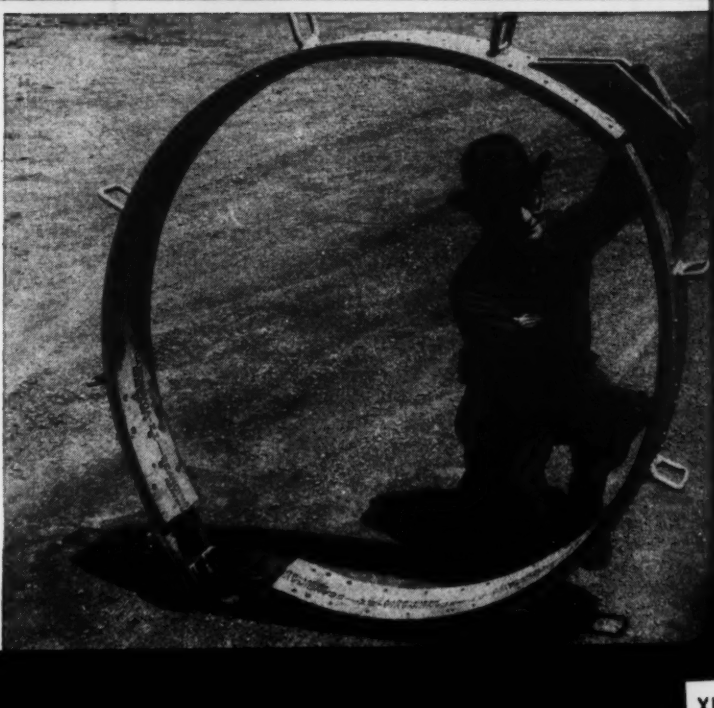
**LINK-BELT COMPANY**: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,258

# HOW USS "T-1" STEEL IMPROVES THESE PRODUCTS...

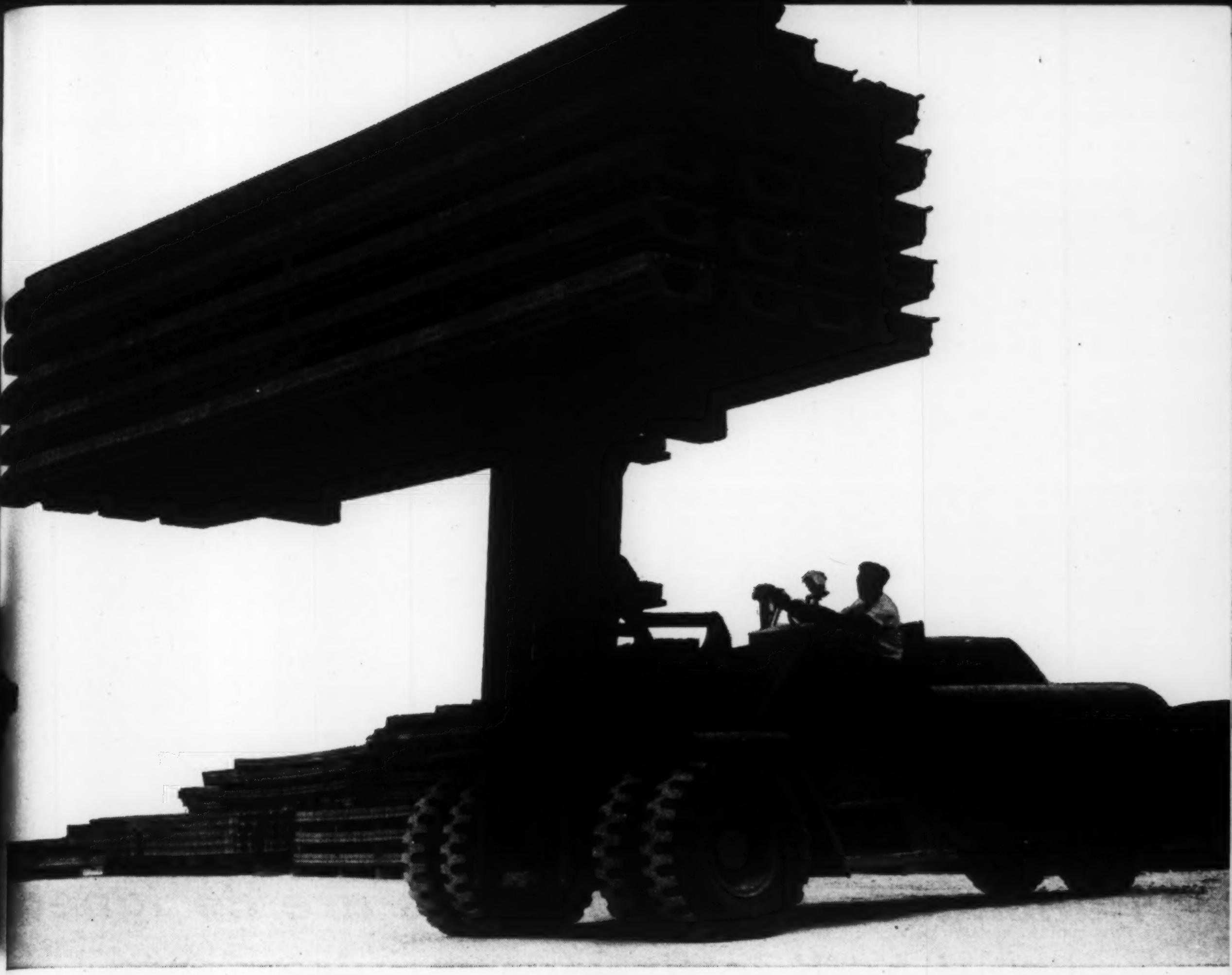
INTERNATIONAL
INTERNATIONAL

**Pays Off In Payloader.** Speed is emphasized in International Harvester's new Model 12 Payloader. That means weight had to be cut. And USS "T-1" Steel helped cut weight of the rugged boom. This remarkably tough, strong steel is used at top and bottom sides where maximum stresses are imposed. The section depth of the USS "T-1" Steel parts is 12 inches. With other, less strong steels, section depths of 19 and 24 inches would have been required—much too large to fit the contour of the machine. USS "T-1" Steel cut size, weight . . . was cold bent, and welded to other parts of the machine by automatic submerged arc welding.

**Stops Brake Breakage.** Columbiana Cylinder Grinding Company, Columbiana, Ohio, does a lot of custom machining on industrial and mining equipment, including repair of brake and clutch bands for large earthmoving equipment. On the original equipment these bands are made of plain mild steel . . . often break under the tremendous stresses encountered. Columbiana replaces broken bands with new ones of USS "T-1" Steel—has yet to have a USS "T-1" Steel band break.



*Circle 431 on page 19*



**More Strength, Less Weight.** This lift truck, in use at Baltimore Concrete Plant Corporation, and manufactured by Gerlinger Carrier Company, Dallas, Oregon, is the largest standard-line lift truck on pneumatic tires in the world. USS "T-1" Steel reduced the width and thickness of the forks on this truck. In addition, this extremely tough constructional alloy steel eliminated the need for shipping the forks 75 miles for heat treatment, which was required with the alloy steel previously used.

## HOW IT CAN HELP YOU

USS "T-1" Steel, with its high minimum yield strength of 90,000 psi and its minimum tensile strength of 105,000 psi, can help you design or build lighter-weight equipment that will last longer. Its unusual toughness can help you design or build equipment capable of taking severe impact and abuse at sub-zero temperatures. Its excellent weldability can help you cut the cost of fabricating highly stressed parts, and reduce repair and maintenance expense. Its good creep rupture strength can help you put more durability in equipment that operates at temperatures as high as 900 degrees F.

Somewhere in your operation, versatile USS "T-1" Steel can help you. Write, wire, or phone United States Steel, Pittsburgh 30, Pa.

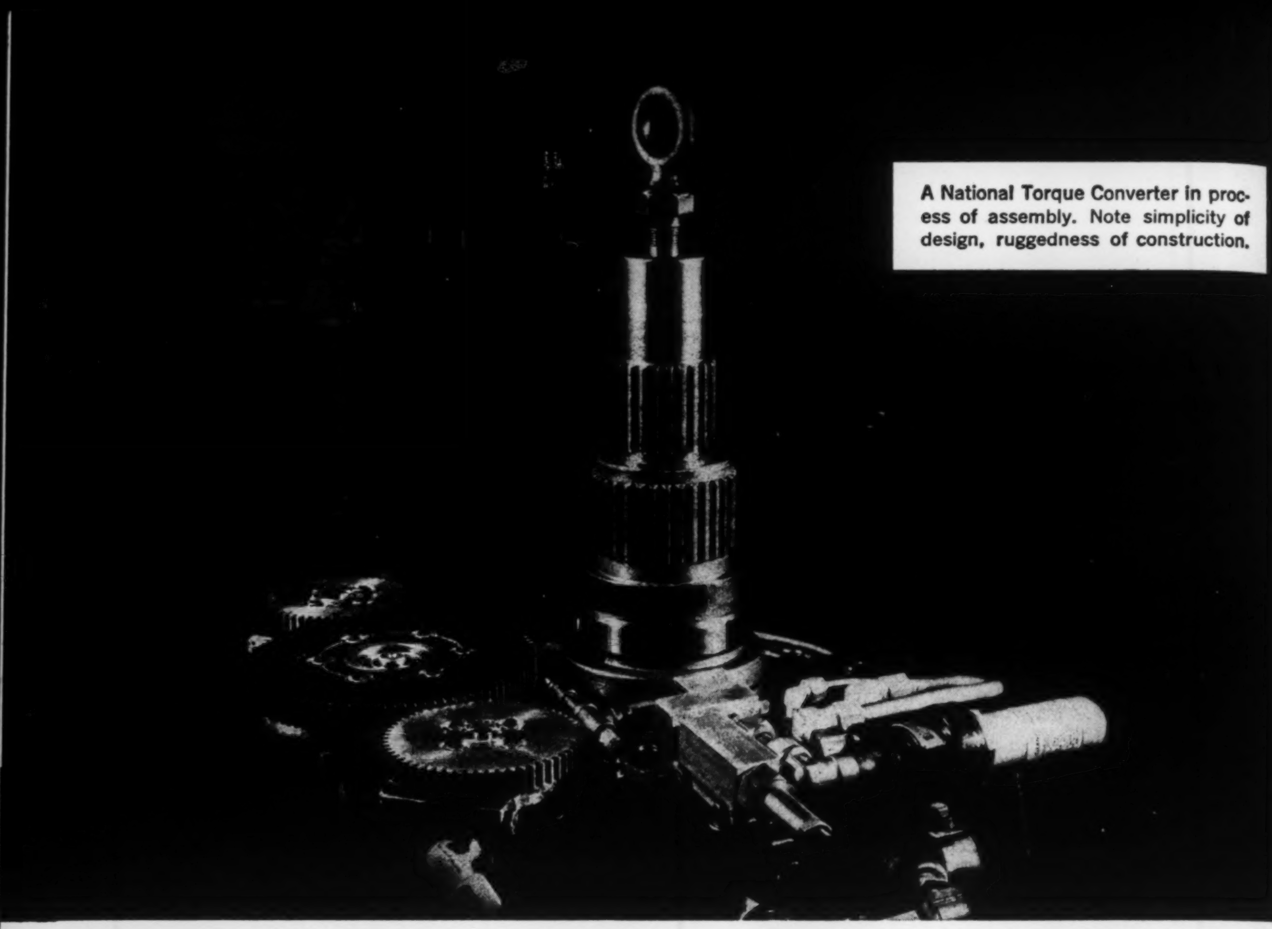
UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

## USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS

See The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL



A National Torque Converter in process of assembly. Note simplicity of design, ruggedness of construction.

# *National Torque Converters are designed and built to fit your requirements*

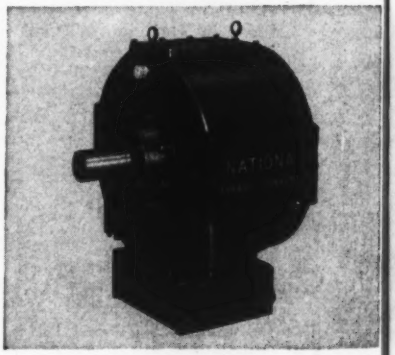
The simple, rugged design of National Torque Converters gives you many outstanding features such as these:

Easy installation of torque converter. Long equipment service life. Minimum maintenance of equipment and torque converter, even in toughest industrial service.

With a National Torque Converter, the engine or motor attains optimum speed quickly . . . delivers full horsepower to the job smoothly and continuously. Your equipment will do more work per unit per operator per day.

You have a choice of 6 basic hydraulic circuit sizes, each with a range of input ratings, permitting exact matching of torque converter to gasoline or diesel engines or electric motors of 100 to 1000 horsepower.

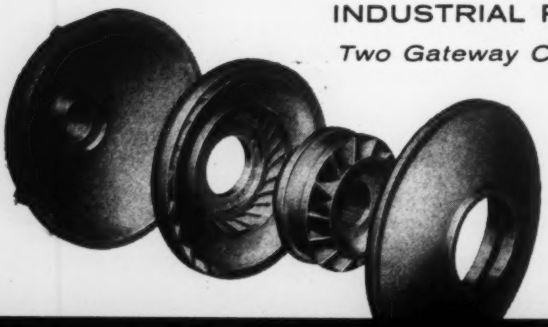
National engineers will gladly work with your designers to find the correct size and capacity of National Torque Converter for the specific power–speed characteristics of your equipment. Why not call on them, and get the benefit of their experience? Write The National Supply Company, Two Gateway Center, Pittsburgh 22, Pa. Ask for a copy of Bulletin No. 468.



## THE NATIONAL SUPPLY COMPANY

INDUSTRIAL PRODUCTS DIVISION

*Two Gateway Center, Pittsburgh 22, Pa.*



*Pace-setters in the progress of industrial power transmission*

**Circle 432 on page 19**

(Advertisement)

# CORNING GLASS BULLETIN

## FOR PRODUCT DESIGNERS

### *Etchings to excite exigent engineers*

Next time someone says, "Make it small and accurate," reach for your file on *photosensitive glass*.

Using a process called "chemical machining," photosensitive glass now yields intricate and accurate components for both electrical and mechanical applications.

Starting with a Corning special glass, chemical machining makes it possible to achieve an intricacy never before thought possible. And it's all done *without* the need for costly grinding, drilling, cutting or engraving.

Let's take a look at some chemical machining in practice, a good example being this wire brush holder for a tiny airborne digital converter.

**Made of glass by a combination of photo, heat and etch processes is this precision brush holder for a digital converter. In background are holders that have been exposed and developed but not yet etched.**

As originally designed, this converter had 0.0065″ single wire brush contacts. Brush holders were of a glass fiber reinforced laminate. But, the smallest holes that could be drilled in this laminated material were 0.015″ in diameter. Result? Loose-fitting wires.

Turning to the miniaturization and precision offered by photosensitive glass, designers came up with a brush holder with *rectangular* holes, 0.0075″ x 0.015″.

Two wires (each 0.0065″) are inserted side by side in each hole. Holes are etched through the glass and have a conical cross section. The lip of this cross section serves as a reference point about which the free ends of the brush cantilever.

Spacing of the slots is held to a tolerance of 0.001″ over 1½″, making it possible to position the double brush contacts with close tolerances.

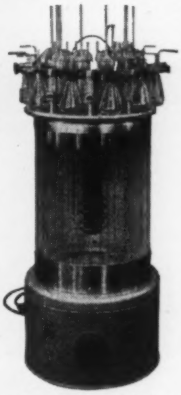
Etched glass also plays a role in assembly, with an alignment plate used to locate the free ends of the brush while fixed ends are cemented.

Behind this *accuracy-by-acid* is some quite ingenious exploiting of differential rates of etching glass. And there's also some interesting use of collimated ultraviolet light and heat.

You can learn a great deal more about photosensitive glass (including other uses) by writing for "Chemical Machining Photosensitive Glass," a reprint of an article that ran in *Materials and Methods*. Free with the coupon.

### *Viscosity, visibility and versatility*

From the production lines of the Precision Scientific Company of Chicago comes this Transformer Oil Oxidation Test Apparatus.



This bit of precise plumbing is a second cousin to another Precision product, the Model "S" Kinematic Viscosity Bath.

Used profusely in both is PYREX brand glass No. 7740. First, there are PYREX brand jars (12″ x 18″) forming the main chambers of the test apparatus. Then you'll find an almost bewildering array of tubes and tubing, some of it quite intricate in shape. And there are also Erlenmeyer flasks and glass umbrellas.

Behind Precision's choice of glass is the need for visibility, plus *accuracy and precision*.

PYREX brand glass No. 7740 handles all these requirements admirably. It's known as the "balanced glass,"—balanced for chemical stability, heat shock and physical knocks.

No. 7740 demonstrates a remarkable reluctance to mix with, or be affected by, what you put *in* or *around* it. Among the usually destructive forces that bother it not at all are most acids and alkalies, as well as steam.

This *not adding to or detracting from* is one reason why No. 7740 is the favorite among those who must protect delicate flavors. That's why, for example, you'll find this glass in coffee makers, both commercial and household varieties.

And PYREX No. 7740 stands up to physical knocks. It takes thermal shocks in its stride, too, having a linear coefficient of expansion of $32.5 \times 10^{-7}$ between 0° and 300° C.

A clear glass, it's available in economical quantities as blown or pressed ware, and in plates, panels, tubing and rod.

Even one-piece molding of fancy shapes has been done with this most popular of all glasses made by Corning.

Can some particularly knotty problem of yours find its answer in this or some other glass by Corning? Good way to start finding out is with our Bulletin B-83, "Properties of Selected Commercial Glassware." It details characteristics of many of the glasses sold under the PYREX, CORNING and VYCOR trademarks.

This basic reference volume is yours for the asking. You can get one quickly by using the coupon.

### *Still available . . .*

"Glass and You," a profusely illustrated volume showing how many businesses and industries use glass profitably.

And there's Bulletin B-84, "Manufacture and Design of Commercial Glassware," a brief summary of design considerations in making glass by various methods; also data on sealing and assembling glass to metal.

Plus an invitation to consult with us via the written word, phone, or wire, on utilization and availability of *glass* as a basic material of design and construction.

With 105 years of experience in glass technology behind us, and with the formulas for some 65,000-odd different glasses on tap, we've acquired quite a bit of useful know-how.

You can make use of it at your convenience. And, if you're in the area, be sure to stop by at The Corning Glass Center. Here you will find both the oldest and the newest uses for glass. We would be glad to send you a preview of what may be seen. Check the coupon.

*Corning means research in Glass*

**CORNING GLASS WORKS, 52-12 Crystal Street, Corning, N. Y.**

Please send me the following material: Reprint, "Chemical Machining Photosensitive Glass" ☐; Bulletin B-83, "Properties of Selected Commercial Glassware" ☐; Illustrated Booklet, "Glass and You" ☐; Bulletin B-84, "Manufacture and Design of Commercial Glassware" ☐; "Your Tour of The Corning Glass Center" ☐.

Name________________ Title__________

Company________________

Street________________

City________________ Zone_____ State__________

Circle 433 on page 19

**Alnico permanent magnets** power the new Eriez Ferrotrap, visible above at left of the paper. Trap body and cover plate are Type 316 stainless chromium-nickel steel, non-magnetic and easy to clean.

# How Alnico guards products and machines ...traps tramp metal continuously

This operator holds a collection of nails, paper clips and other ferrous contaminants. All were removed by the Eriez Ferrotrap from liquid caramel being pumped through a candy plant pipeline.

Keeping hot, viscous caramel free of tramp iron is an obviously difficult task. But a new Eriez unit, aptly named the Ferrotrap, does this sort of job with multiple rods or "fingers" containing Alnico permanent magnets.

No need for electromagnets, current and accessories, because at temperatures up to 850°F the powerful, life-time magnetic strength of a high nickel alloy ... Alnico ... assures positive trapping of iron particles. Even nuts, bolts, and the like.

Units that protect not only product purity, but also filters, mixers, pumps and other costly equipment are made practical by the powerful magnetic properties of Alnico, an aluminum-nickel-cobalt-iron alloy.

Nickel ... an essential element in Alnico ... improves hundreds of other alloys utilized in industry. So if you have a problem involving metals, consult us on the use of nickel or nickel alloys. But if you wish further information about the Ferrotrap, write Eriez Manufacturing Company, Erie 6, Pennsylvania.

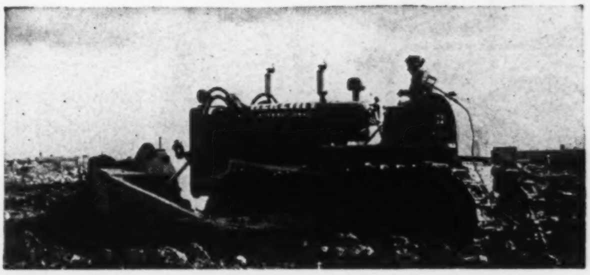
INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.**

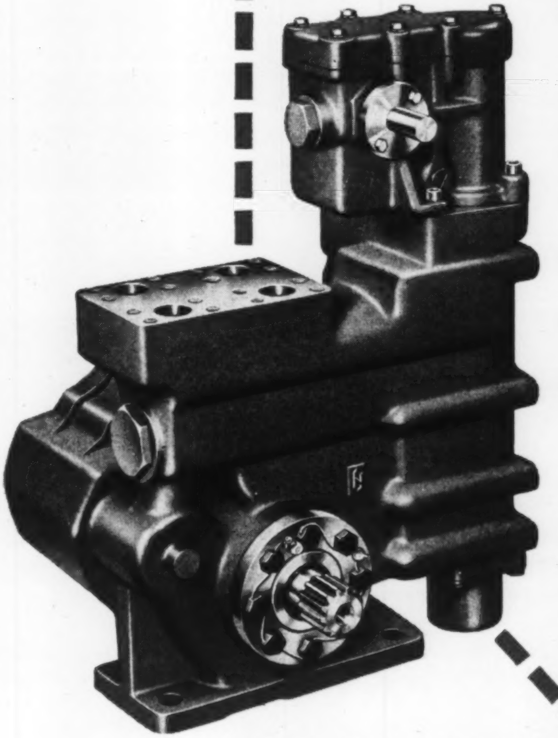
67 Wall Street
New York 5, N. Y.

# CUSTOM DESIGNED
# FLUID POWER SYSTEMS
# Start with HYDRECO®

## THE PROBLEM · · ·

To provide a hydraulic system for complete control of a large bulldozer affording sensitive and positive operation of the blade. The system must be extremely rugged, of minimum weight, capable of handling upwards of 160 hp and compacted into definite space limitations.





HYDRECO Fluid Power Unit combination for International Model TD-24 Bulldozer. Rated 160 gpm at 1600 rpm — 1475 psi.

## THE SOLUTION · · ·

HYDRECO engineers, drawing upon years of experience in solving Mobile Equipment problems, CUSTOM DESIGNED the unit shown at the left. Here, in a single assembly incorporating Pump, Control and Auxiliary Valves, HYDRECO engineers effect an answer which precisely meets all of the requirements for the International Harvester TD-24 Dozer . . . RUGGEDNESS . . . COMPACTNESS . . . WEIGHT ECONOMY . . . PERFORMANCE AND PRICE.

The ability to CUSTOM DESIGN for the specific need can be a highly advantageous facility for YOU. CUSTOM DESIGNING serves to complement the complete line of HYDRECO Fluid Power Pumps, Motors, Valves and Cylinders which are "standard" for so many famous names in Mobile Equipment.

Write for Bulletin No. 400 describing new developments in HYDRECO FLUID POWER. Your inquiry on specific design problems is a challenge the HYDRECO engineer likes to see.

*Write—*

KALAMAZOO Division
The New York Air Brake Company
9006-12 E. Michigan
Kalamazoo, Michigan

Gentlemen:
Please furnish the following:
☐ Copy of Bulletin No. 400.
☐ Further information on HYDRECO CUSTOM DESIGNING.

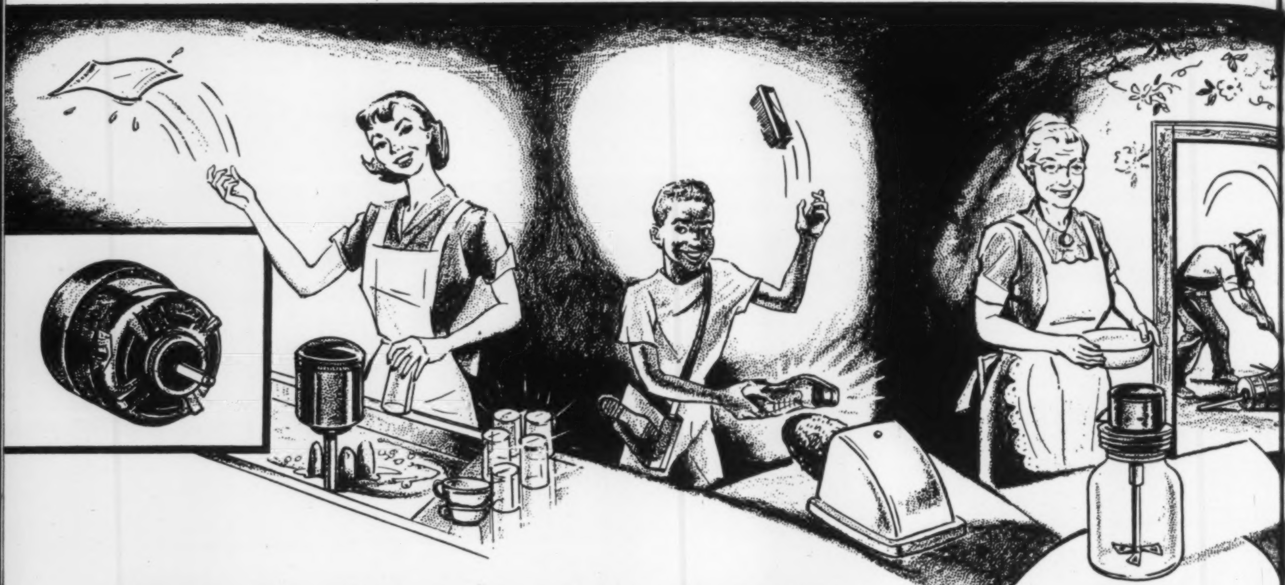
Name ____________________
Company ____________________
Address ____________________
City ____________ Zone ______ State ______

Member NFPA

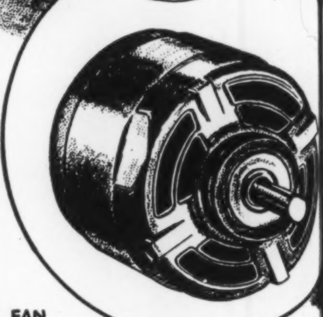
NFPA NATIONAL FLUID POWER ASSOCIATION

**KALAMAZOO DIVISION**
**THE NEW YORK AIR BRAKE COMPANY**
9006 E. MICHIGAN · KALAMAZOO · MICH.
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

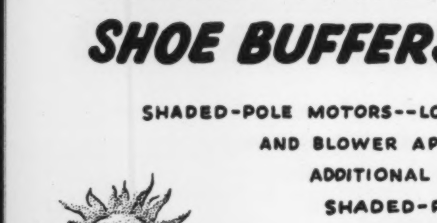
# DESIGN SOLUTIONS with G-E



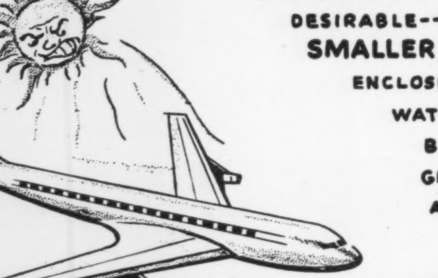
## NOW, SHADED-POLE FAN MOTORS USED ON MANY LABOR-SAVING DEVICES SUCH AS GLASS WASHERS, SHOE BUFFERS, BUTTER CHURNS



SHADED-POLE MOTORS--LONG KNOWN AS **SMALL, LOW COST** MOTORS FOR FAN AND BLOWER APPLICATIONS--ARE NOW USED IN A MYRIAD OF ADDITIONAL APPLICATIONS. GENERAL ELECTRIC **PERMANENTLY-LUBRICATED** SHADED-POLE MOTORS HAVE MANY FEATURES WHICH MAKE THEM DESIRABLE--**SUPERIOR VENTILATION--MOUNTING FLEXIBILITY--SMALLER DESIGN--ALL-ANGLE OPERATION**--CHOICE OF OPEN, TOTALLY ENCLOSED OR TOTALLY ENCLOSED FAN-COOLED MODELS--RATINGS 1.5 WATTS- 1/4 HP. TYPICAL APPLICATIONS ARE ELECTRIC SHOE BUFFERS FOR THE HOME AND OFFICE--BUTTER CHURNS--DISH AND GLASS WASHERS IN RESTAURANTS--SANDERS--AQUARIUM AIR AND WATER PUMPS--SUMP PUMPS--AND MANY OTHERS.



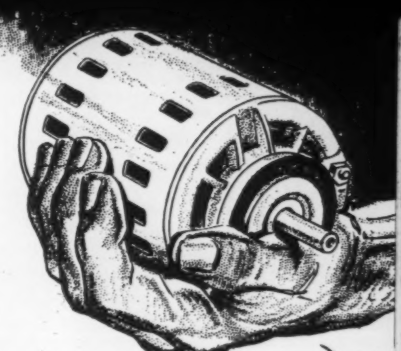
## AIRLINERS COOLED BY HERMETIC MOTOR PARTS LESS THAN 6½ INCHES IN DIAMETER--25 HP DELIVERED CONTINUOUSLY AT 23,500 RPM.



HERMETIC MOTOR PARTS WITH **DIAMETER OF ONLY 6 5/16 INCHES WEIGH ONLY 18 POUNDS**--YET DELIVER 25 HP CONTINUOUSLY AT A SPEED OF 23,500 RPM!

DESIGNED TO POWER AN AIRBORNE COMPRESSOR, THESE PARTS-STATOR, ROTOR AND SHELL-ARE COOLED BY FREON CIRCULATING THROUGH THE SEALED PARTS. THE COMPACT TWO-POLE, 400-CYCLE CONSTRUCTION MAKES POSSIBLE A CONTINUOUS 25 HP RATING.

# specialty motors



## *QUIET, COOL-RUNNING G-E 1/20 HP MOTOR VIBRATES ELECTRONIC ORGAN REEDS; ELIMINATES GEAR UNIT*

ORIGINALLY, WURLITZER CO. ENGINEERS USED A MOTOR AND GEAR IN A SOUNDPROOF HOUSING TO POWER A BLOWER WHEEL FOR VIBRATING ORGAN REEDS. BUT BY SWITCHING TO A G-E 3450-RPM 1/20 HP SMALL INDUCTION MOTOR, THEY WERE ABLE TO **ELIMINATE THE GEAR UNIT ENTIRELY.** ALSO, THE EXTREME QUIETNESS OF THE COMPACT LITTLE MOTOR ENABLED THE ORGAN DESIGNER TO MOUNT THE MOTOR OUTSIDE OF THE SOUNDPROOF HOUSING!

AFTER THE MOTOR-POWERED BLOWER STARTS REEDS VIBRATING, THE ORGANIST TOUCHES KEYS AND A METALLIC PICK-UP ARM FEEDS VIBRATIONS INTO AN ELECTRONIC SYSTEM TO THE AMPLIFIER. THE RESULT: **SOFT ELECTRONIC MUSIC WITH THE HELP OF A G-E MOTOR!**

## *AVAILABLE: COMPLETE FHP MOTOR ENGINEERING ASSISTANCE FOR YOU!*

HERE'S THE SPECIAL ATTENTION YOUR SMALL-MOTOR PROBLEMS GET AT G.E.

**1**

YOUR LOCAL G-E APPARATUS SALES ENGINEER LEARNS ALL ABOUT YOUR MOTOR NEEDS

**2**

HE CALLS A TEAM OF FACTORY ENGINEERS WITH YEARS OF MOTOR APPLICATION EXPERIENCE

**3**

AT THEIR DISPOSAL ARE G.E.'S COMPLETE DEVELOPMENT AND TESTING FACILITIES

**4**

IN SHORT ORDER A SAMPLE G-E MOTOR IS READY FOR TESTING ON YOUR PRODUCT

**FOR THIS COMPLETE HELP,** CONTACT YOUR NEARBY G-E APPARATUS SALES OFFICE TODAY.

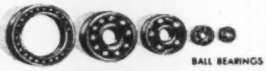
WRITE FOR FREE BULLETINS COVERING G-E EQUIPMENT DESCRIBED IN THIS AD TO GENERAL ELECTRIC CO., SECT. 632-6, SCHENECTADY 5, N.Y.

*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**

Circle 435 on page 19

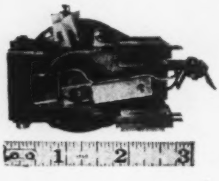
# Haunted by a Horse?

**Got a problem in power capsulation, weight and size reduction, design diminution? — so horsepower is giving you the horrors? More than 500 types and sizes of MPB's* such as these**  **can help to make your horsepower headaches smaller, lighter and easier.**

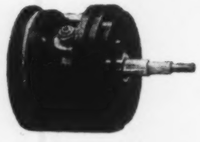
BALL BEARINGS ACTUAL SIZE

---

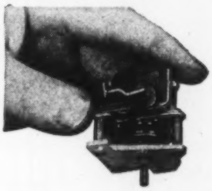
## MPB's* at work



An MPB radial bearing translates rotary to lineal motion in this fire control relay. It increases sensitivity and dependability while reducing wear and withstanding severe shock loads.



Miniature gear differential designed to permit coaxial shaft mounting on one end of housing. Seven MPB flanged radial bearings and two superlight radial bearings are used in each unit.



Indexing mechanism using MPB miniature bearing as an index pawl operated by the miniature solenoid at top. Friction clutch drives index disk, allowing overtravel when rotator is suddenly stopped.

***MINIATURE PRECISION BEARINGS, INC.**

**3 Precision Park, Keene, N. H.**

oing

# DU PONT ELASTOMERS

NEOPRENE · HYPALON®

in Design

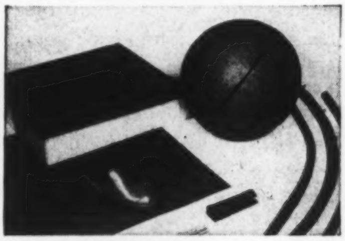
## Coatings of HYPALON® add beauty and durability to a variety of products

Du Pont's new synthetic rubber, HYPALON, can now be applied as a protective coating on rubber, metal, wood or fabrics. It can be applied by spraying, brushing or spread coating. The development of these coatings, both clear and colored, has opened new avenues of product design in a wide range of applications. Here are the advantages such coatings offer:

HYPALON is unaffected by ozone. It has unusual resistance to hardening at elevated temperatures (250°-350°F.). It is unique in its resistance to weathering and oxidizing chemicals. And, in addition to the protective benefits of HYPALON coatings, an unlimited range of stable colors is available to add beautiful and functional color to your products.

Applications for HYPALON coatings include tank linings, footwear, tarpaulins, camera bellows, hose, belts and automotive and sporting equipment. For other uses see the photograph below.

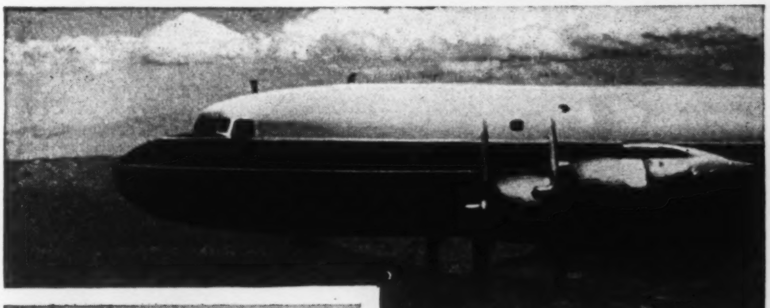
How can coatings of HYPALON fit into your design problems? Mail the coupon for more detailed information about your specific problem.

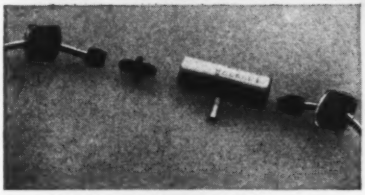


**These products feature attractive protective coatings of HYPALON:** a piece of corrugated rubber mat (left foreground); a coil of electrical wire, and a child's overshoe on the mat; rubber extrusions for automobile windshield frame and trunk weatherstripping (center foreground); door weatherstripping (right foreground); slab of urethane foam (left rear); basketball (right rear).

*Circle 437 on page 19*

## NEOPRENE SEALS safeguard fuel line connections in the Douglas DC-7





SEAL READY FOR ASSEMBLY

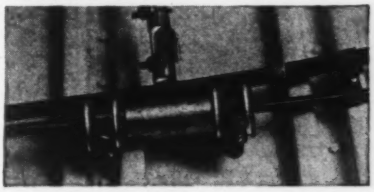
**Safety of passengers** is uppermost in the minds of Douglas Aircraft designers—even down to as small an item as the rubber sleeve on a fuel line connector. Douglas uses the best metal connectors to join its fuel lines, but as an additional safety factor the company fits a vapor-tight sleeve seal over each joint which is vented by tubing to the ship's exterior to prevent any possible accumulation of highly flammable gasoline vapors within the fuselage.

Before switching to neoprene, Douglas had a problem with the seals. They required frequent replacement because ozone caused the rubber to crack. In fact, many of the rubber seals were rejected as unusable before installation because of ozone cracks which developed while the pre-assembled units were held in stock.

The installation of neoprene seals proved to be the answer to the problem. Neoprene was chosen because it resists ozone, gasoline, oil and aging. Many of the neoprene seals have been in service for over two years, reducing maintenance and replacement costs.

Perhaps your design problems can be solved by the use of Du Pont neoprene. We'd be glad to send you further information—property data and proven applications. If you have a specific problem, please let us know in the coupon.

**NEOPRENE SEALS (in red) resist ozone, oil, gasoline and aging. Many of them have lasted for over 2 years.**



DU PONT
REG. U. S. PAT. OFF.

***HYPALON** is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

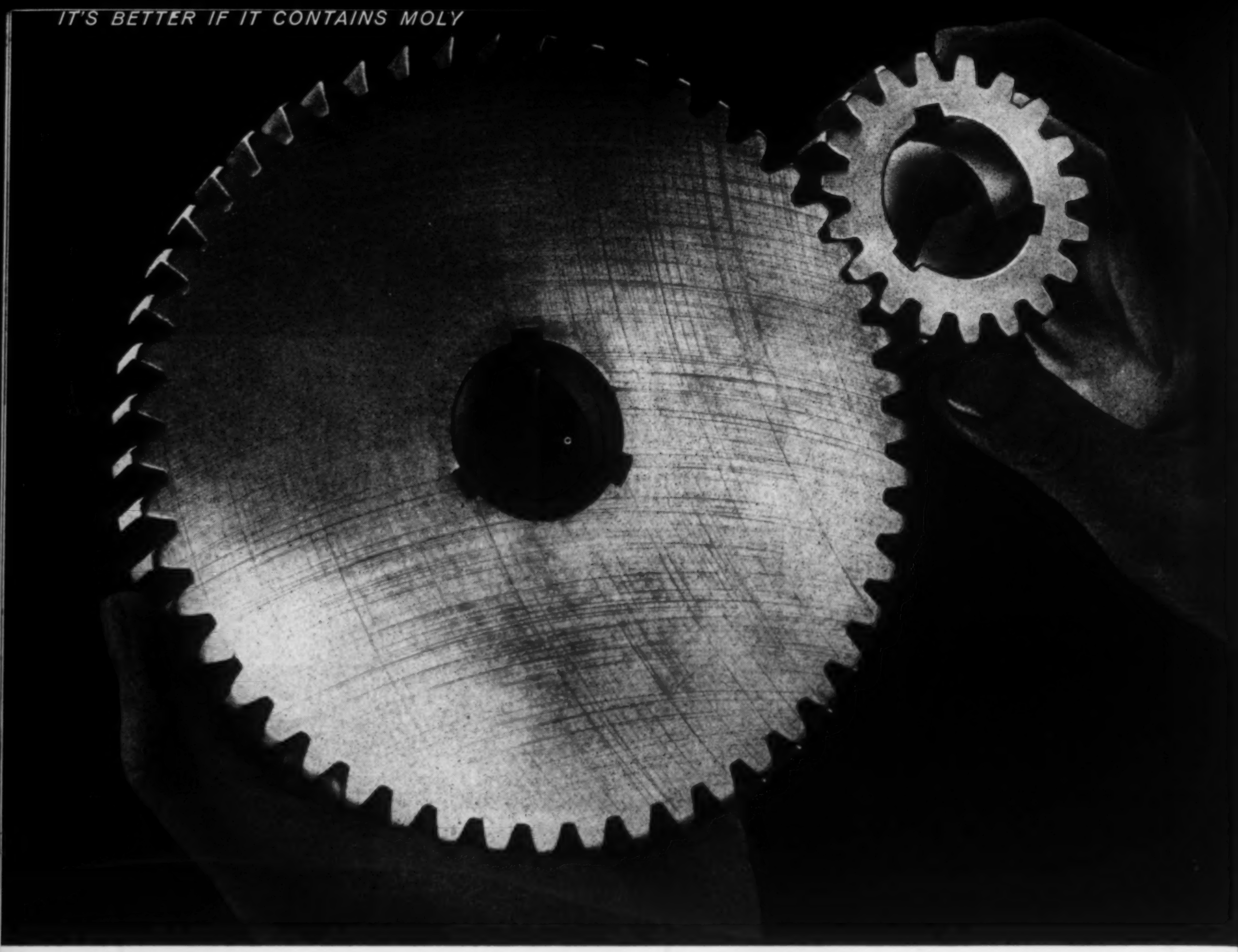
**BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY**

☐ I am particularly interested in____________________________

☐ Please add my name to the mailing list for your free publications, "The Neoprene Notebook" and "Facts about HYPALON."

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. MD-12
Wilmington 98, Delaware

*Name*____________________________
*Firm*____________________________
*Address*____________________________
*City*__________________ *State*__________



# Up to 1% Moly in carburizing steels gives required hardenability economically

Why limit the use of molybdenum to the .15/.25% Mo and .20/.30% Mo contents of the traditional grades? For the contributions of moly do not stop there. Laboratory tests and production runs prove that as molybdenum contents increase up to 1%, hardness increases progressively. A wide range of case and core hardenabilities, therefore, can be obtained – economically, too.

Tests with a series of molybdenum-manganese steels show that these compositions give higher case hardness on a direct quench than other steels of comparable core hardenability. One extensively tested composition, for example, is 0.5% Mo – 0.5% Mn steel. It shows longer life, and is lower in cost than steels previously used. And it produces a higher case hardness with similar or less distortion. What's more, tool life and surface finish are equal or better. Good reasons why several companies have already adopted this grade for automotive gears and other critical applications.

If you use carburizing steels, see what a higher molybdenum content can do for you. Part of the story is contained in the technical article "New Carburizing Steels For Critical Gearing." For your copy, or other technical data, write Climax Molybdenum Co., Dept. 11, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM

Use the
Moly Key
to better
carburizing
steels

- High case hardness
- Wide choice of hardenability
- Easy to heat treat
- Low distortion
- Good machinability
- Good wear resistance

**CLIMAX MOLYBDENUM**

*Circle 438 on page 19*

# World's tallest pile driver...

# World's toughest test rig...

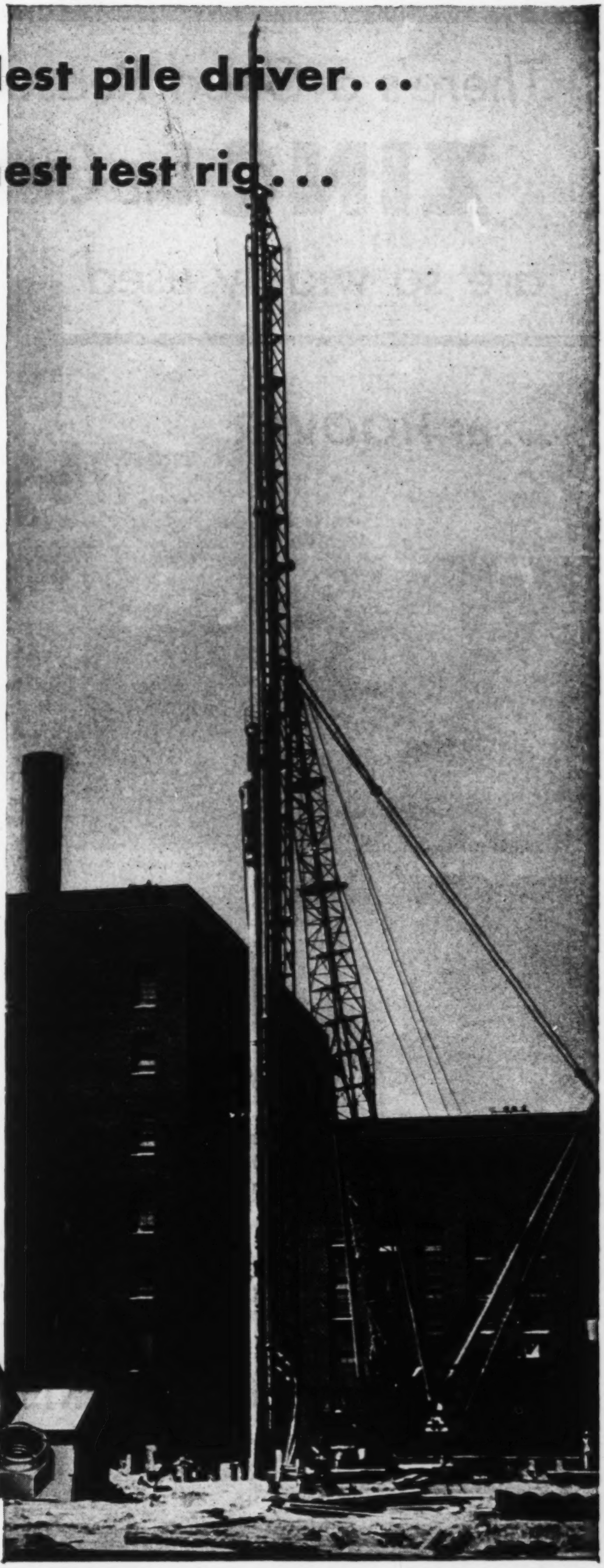
# for

# Elastic Stop® nuts

Each hammer-stroke of this 270-foot pile driver delivers a 24-foot-ton wallop! It was built by Raymond Concrete Pile Company to drive 200-foot pipe piles for the foundation of units being added to the B. C. Cobb Steam Plant of Consumers Power Company, at Muskegon, Mich.

Raymond makes a practice of using Elastic Stop® nuts for bolting together sections of leads and booms on all their pile-driving equipment. The red elastic locking collar of these vibration-proof fasteners has successfully maintained its grip under these severest of all vibration and impact conditions!

Whether used on aircraft or locomotives; guided missiles or steam shovels . . . more than twenty years of field testing on applications where safety and severe operating conditions demand a fastener that will not shake loose, prove that . . . *you can rely on Elastic Stop nuts.*



**ELASTIC STOP NUT CORPORATION OF AMERICA**

**Department N77-124 • 2330 Vauxhall Road • Union, N. J.**

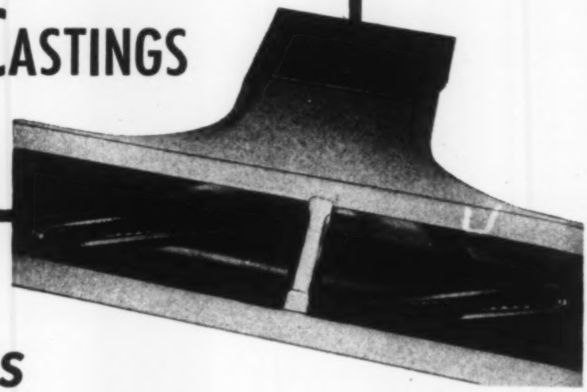
**The red locking insert in an Elastic Stop nut guarantees**

- reusability
- vibration-proof locking
- thread sealing . . . no galling
- immediate identification
- adaptability to all shapes and sizes of threaded fittings
- suitability to production line assembly methods

ESNA® TRADE MARK

*Circle 439 on page 19*

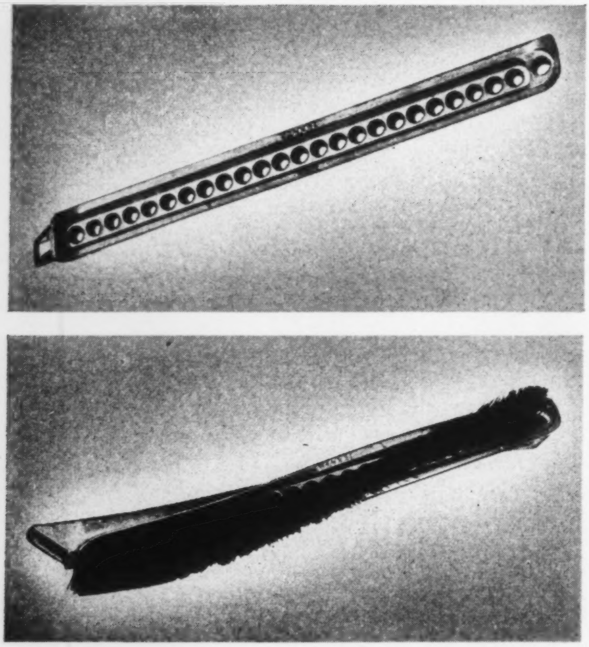
# *There's a Good Reason why*
# **ZINC** DIE CASTINGS
# *are so widely used*



## ***. . . at HOOVER***

## ***. . . IT'S***

# ***DUCTILITY***



**The straight die casting (at top) is put into production without any machining. The bristles are fastened in place and the forming operation twists the bar to the proper curvature for installation on the agitator.**

Design engineers at The Hoover Company found that DUCTILITY provided the necessary answer to their problem of using ZINC Die Castings in the agitator of the upright electric vacuum cleaner.

Because of the helical contour of the brush, the metal back could not be die cast to the required shape since the anchoring holes for the bristles would not be parallel to the motion of the die. The problem was neatly solved by a die caster who knew how to use the exceptional qualities of ZINC Die Castings.

The brush backs were cast straight, the bristles anchored in the holes and the castings were then cold formed approximately 115° to give the necessary helical contour. Even with the extra forming operation, die casting proved to be the most economical method of production since no machining was necessary.

Ductility is just one of the many physical and mechanical advantages that make ZINC Die Castings so widely used by manufacturers who want the best product with lowest costs of parts and assemblies.

**ZINC**
**FOR DIE CASTING ALLOYS**

**THE NEW JERSEY ZINC COMPANY** ***160 Front Street, New York 38, N. Y.***

**The research was done and the Zamak die casting alloys were developed with**
**HORSE HEAD SPECIAL ( 99.99 + % Uniform Quality ) ZINC**

MACHINE DESIGN
DECEMBER 27, 1956

# A Design Machine?

PROMINENTLY featured in the November issue of *Fortune* is a proposed "design machine" which is offered as one of several ideas for accelerating research and engineering methods to match production speeds.

Pictured at the control console is an "engineer" who has just typed out a description of a part, which the machine has promptly revealed to him as a 3-D view on a screen.

There's only one snag in this hopeful picture. The machine has not really "designed" the part. That has obviously been done already, as evidenced by a pencil sketch which was the operator's guide in punching the machine's keys.

So the function of the machine is basically that of drafting—establishing exact dimensions for parts whose general configuration is already known. As an extension, this machine of the future would also control directly or through tapes the power tools to produce the part.

Such a device conceivably could be a useful aid in speeding-up engineering development, but let's not call it "design" or its operator an "engineer."

At the other end of the scale is a very different sort of activity, one which is engaging more and more engineers today but for which there are no foreseeable machine aids—organizing large engineering projects.

Mobilizing immense throngs of engineers and scientists for the design and development of huge, complex and hitherto unheard-of machines and systems offers challenging problems—organizational, technical and human.

H. F. Lanier's thought-provoking article beginning overleaf gives a glimpse of what's ahead for engineers in this area of endeavor. His picture of the inputs and outputs which the creative engineer's brain must process is all the evidence needed to dispel the notion that a true "design machine" will ever cause technological unemployment among engineers.

Colin Carmichael
EDITOR

# *Organizing for* Large Engineering Projects

By H. F. Lanier, *Project Engineer*
*Aerophysics Departments*
*Goodyear Aircraft Corp.*
*Akron, Ohio*

**Organizing engineering for maximum results in minimum time is no small task. But when projects become huge and complex, the problems can grow to staggering proportions.**

**Such projects—current and contemplated—are demanding a new approach to engineering organization.**

**Here's an analysis of the problem and suggestions on how it can be solved. Although concerned primarily with large-scale engineering programs, this discussion may also provide helpful viewpoints for operations of any size.**

ENGINEERING organization is undergoing a revolution. This has been brought about by the advent of new large projects, the shortage of engineers and a general increase in complexity of engineering problems. Perhaps the most action can be seen in the engineering of large systems such as the Air Defense System, various guided missiles, and color television.

A typical large engineering project employs a team of specialists who must work closely together and be supervised by one of their number. These teams, as defined here, include subprofessional engineering aids, but do not include such things as plant engineering, tool engineering, and similar functions. This distinction is, however, being modified in some companies.

In numbers these teams vary from 200 to 2000 men. But 4000 to 6000-man teams are foreseeable and undoubtedly will come to pass. There appears to be at least one effort that requires a 20,000-man team.

## Need for Co-ordination

The problem of organizing such a team is in the broadest sense that of arranging and guiding a large number of diversified people so they all think productively on facets of a single problem without too much overlap and with complete coverage.

The basic unit of this team is the creative, specialized engineer. He must be free to invent, yet thoroughly bound to co-operative effort. He must communicate a picture of his end product to many people long before it is finished. The many and varied "inputs" and "outputs" he must contend with are depicted in Fig. 1.

**Traditional Approach:** The tradition of proper line organization doesn't fit this man, and it obviously is difficult to maintain a large number of such men in close harmony, and simultaneously get work done efficiently.

The problem can perhaps be best illustrated by considering the difficulties of trying to fit a number of creative people into the precise and orderly line organization shown in Fig. 2. Under this plan, all work is thoroughly organized and all assignments rigidly controlled. Each individual has a definite area to cover, definite data to work with, and a schedule to meet. He also has a boss who tells him what to do and subordinates whom he tells what to do. This organization once set up is soon limited to the creative output of a few men who lead. Any innovation is difficult to introduce because it requires detailed instruction at all levels.

**Lines of Communication:** Large problems must be broken down by someone into blocks that fit together. Then these blocks must be broken down

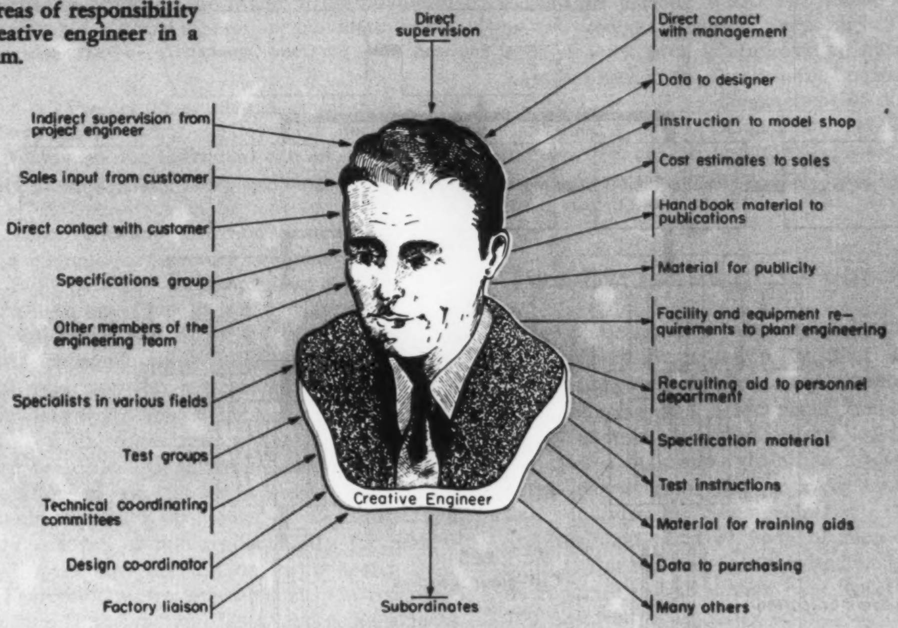

Direct supervision
Indirect supervision from project engineer
Sales input from customer
Direct contact with customer
Specifications group
Other members of the engineering team
Specialists in various fields
Test groups
Technical co-ordinating committees
Design co-ordinator
Factory liaison
Creative Engineer
Subordinates
Direct contact with management
Data to designer
Instruction to model shop
Cost estimates to sales
Hand book material to publications
Material for publicity
Facility and equipment requirements to plant engineering
Recruiting aid to personnel department
Specification material
Test instructions
Material for training aids
Data to purchasing
Many others

**Fig. 1—Lines of communication and areas of responsibility for the creative engineer in a project team.**

further until the tasks are of one-man size. Since each man is a specialist in a different area, his block is an apple in a basket of eggs to his view. He can only carry out his own assignment to the satisfaction of his boss.

To illustrate this, suppose a simple plot must be developed into a TV play. To speed the process, a chief writer divides the plot among four assistants as follows: (1) A miner finds uranium (2) but is shot by his partner (3) who then can't find his way (4) out of the woods. Each assistant must write so many minutes of play around his phrase. Then all are assembled into the final production.

The complication is obvious and the need for coordination very great. When this assignment is carried on to the next echelon, where each man gets one word to elaborate on, the difficulties are ridiculous. Yet examine a realistic case. A multimillion dollar project is started by a work statement as follows:

> Develop, design, and test a guided missile to fly at $w$ altitude for $x$ miles, carrying $y$ pounds of warhead. Include all ground support equipment, spares, test equipment, special tools, manuals, training aids, etc., that may be required. Provide drawings, tools and facilities for $z$ units and actually manufacture certain samples. Provide the whole set simultaneously and in a short time.

It may seem absurd but hundreds of people in this country were given assignments such as: Provide test equipment for the missile specified in this paragraph. One word out of a novel to expand upon! Obviously, those who succeeded didn't take their assignment at face value. They effectively redefined their assignment in some fashion to face an otherwise impossible problem. The major step is somehow to break down the long lines of communication.

## Methods of Approach

In defense of management which passed out such assignments, the organizations in question had a habit of succeeding on large problems. Many perturbations were experienced apparently because two important factors were misjudged: (1) time per development cycle and (2) number of research problems and development tasks which must be integrated into one item.

**Time Factor:** Established industries, such as transportation, have problems in all areas, but usually operate on a long time cycle—perhaps twenty-five years for introduction of anything really different in the way of an overall system. The number of tasks and problems may be several thousand. It hasn't been possible to observe the organizational problems clearly in this area because of the time span involved. A mod-

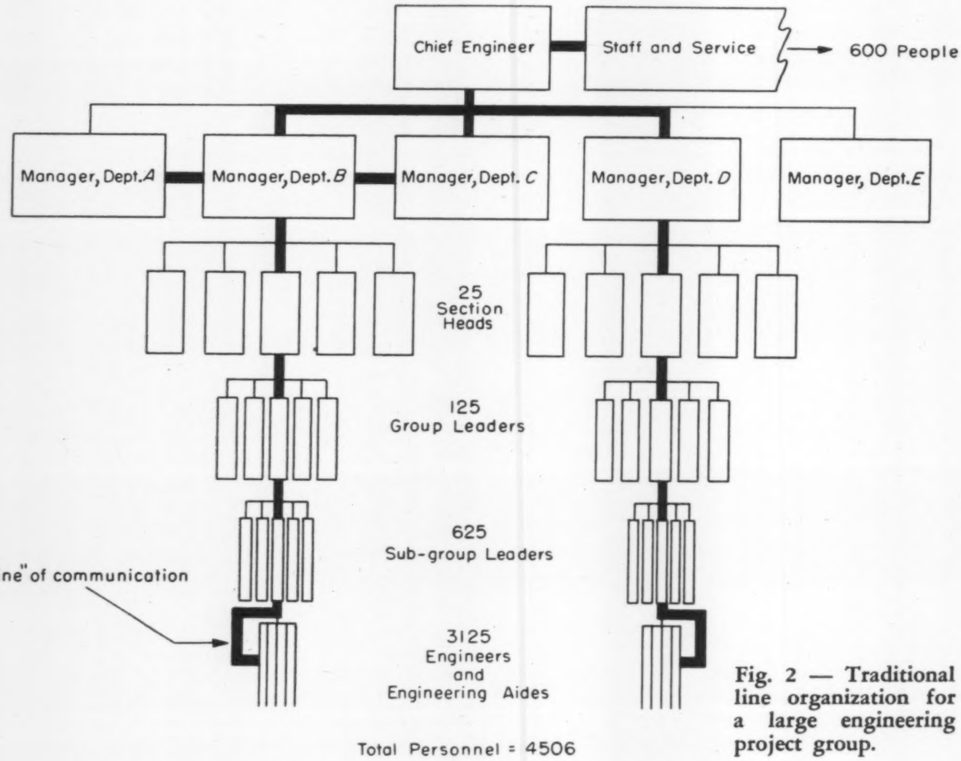


Fig. 2 — Traditional line organization for a large engineering project group.

ern military project may have approximately an equivalent number of tasks condensed into five years.

As a result, military large systems which have a tendency to be hurried to the limit of reason offer a useful laboratory for examining problems in the organization area. The hurry provides a cause and effect cycle short enough to let observers use the results of one project to improve the next. Furthermore, the problems are exaggerated and can readily be seen.

The usual solution was to allow a great deal of "co-ordination" and "liaison" to be handled informally. Effectively, supervisors unleashed their men and gave the program general direction but let detailed instructions be formulated after the fact. The loose method has been reasonably successful. The next obvious step is to attempt to systematize the process. Some new engineering disciplines seem called for and it would be well to train the required people by direct methods to facilitate rapid formation of new teams.

Of course, the organization must be assembled mostly from people of recognizable types. It is possible to develop some new specialties and otherwise modify people in time, but each such operation involves a considerable effort and cannot be entered into lightly, especially since wrong action could head the individuals concerned down a blind alley.

For this reason and others, most of the new organizations have been entered gingerly. Interim arrangements are common. However, as with most problems, the few wholehearted attacks have been most successful.

**Application of Interim Arrangement:** One outstanding example of the interim type is the National Television Standards Committee in its attack on color TV problems. Here, a system needed developing. Yet in no one company was there enough talent, capacity, salesmanship, information, etc., to do the job. The number and diversity of problems were not only beyond any one man's capacity to understand and tie together, they were beyond any one company's capacity.

In this case thirty companies combined forces to specify the color television system in detail, check their theories, assure themselves that all necessary apparatus was practical, and sell the whole thing to the government and the nation. The process used was a committee action wherein individuals were assigned areas to report on and all conclusions were presented through a chain of command, eventually being agreed to by all concerned.

Although ponderous in layout, this scheme was spectacularly successful. The process superficially resembles a diplomatic conference in technique; yet it actually produced the design of an advanced and acceptable system where normal engineering development processes did not.

**Effect of Project Size:** On a small scale, the same technique is being applied to projects of all sizes. Where no one individual can encompass the complete understanding required to make technical decisions, a committee is formed to discuss and recommend. This has one real drawback: Usually the committee members are also line supervisors and hence can meet only for a fraction of the time required for efficient system development. In other words, actual development by committee is employed most effectively on an occasional relatively huge problem.

When large systems problems are the prime business of an organization, then a permanent fix must be made. Here the solution seems to be a committee of project or systems engineers—individuals trained to be jacks of all trades, and who are relieved of line responsibility for administering operating sections but who spend their time (1) developing systems as such, (2) receiving information from labs and tests, and requirements from outside, (3) having the required work done elsewhere and (4) co-ordinating the whole thing.

The project engineer is a feature as old as engineering. Groups of project engineers working in team effort under a project management is a little new.

The project-line combination organization has existed in various forms for some time, usually as a special purpose, temporary thing. Now enough work of the large system nature is under way to warrant the formation of permanent establishments geared to development of large systems. Continued existence of such an operation will permit growth of the specialized people required to make operation smooth and acceptance of new tasks routine.

## Two-Dimensional Organization

Several companies are experimenting with the arrangement illustrated in Fig. 3. Here specialized creative engineering groups are given a two-dimensional supervision. A line supervisor heads a number of groups of related technical skill and training, and a task supervisor heads an array of diverse groups employed on a particular task. A line supervisor is responsible for (1) assembling and training a stable body of men of a certain skill, (2) organizing facilities and assigning groups as required to accomplish its appointed tasks and (3) assuring the quality of output. The task engineer is responsible for (1) fitting together all facets of a broad task, (2) arranging for accomplishment of subtasks by line groups, and (3) providing and fostering the necessary communications and direction to keep all working to the same aim and the right aim.

In addition, the manager of all task engineers

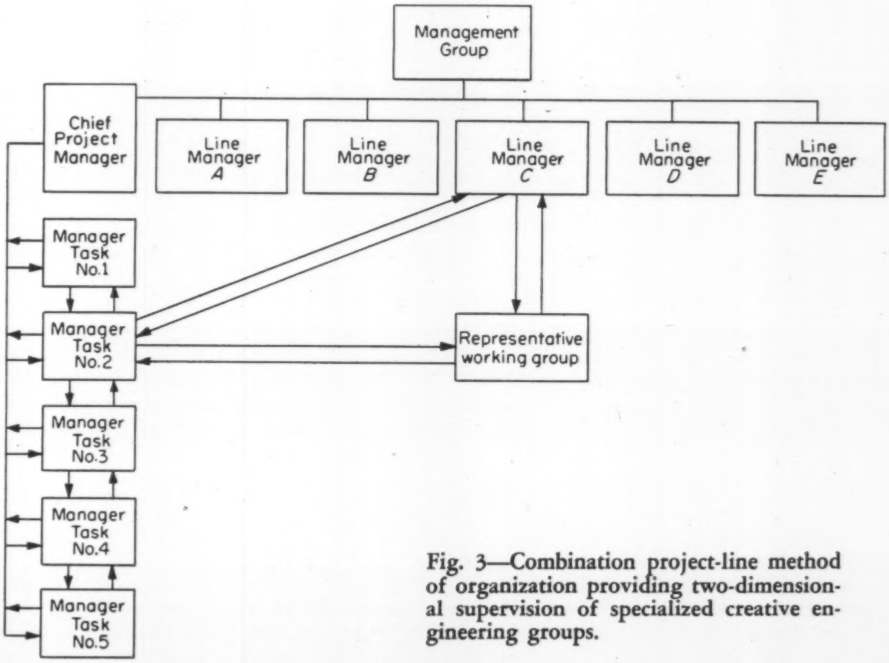


Fig. 3—Combination project-line method of organization providing two-dimensional supervision of specialized creative engineering groups.

has the responsibility for developing the technique of task engineering and training a body of task engineers to work together.

**Personnel Relationships:** As one would expect, to make this approach work requires a great deal of effort. The personnel concerned must be, to some extent, retrained and fitted into the pattern. Successful efforts of this type have been in process for two years or more and still require a constant training activity.

The relationships between supervision and subordinate, and group with group, are obviously complicated by this arrangement. Actually, the formal arrangements are complicated to match more nearly the actual, informal arrangements. Still, it isn't obvious to everyone that this is so and much discussion is required to reach amicable understanding.

**Need for Specialization:** The size of such organizations now in existence varies from about five specialized departments with five distinct tasks to twelve departments with twelve tasks. It seems to follow that, as the overall size grows, the number of recognized separate specialities increases. For example, a reliability function is recognized separately in many companies. This is brought about by the need for near perfect performance in systems at a time when very few or only one such are in existence. Clearly one can't afford to discard the first few defective units off an assembly line when the units cost a million dollars each.

One interesting function of a reliability group is to predict the best moment to fire a missile. Fig. 4 is an example of a probability of success curve. The probability of 0.7-hour successful flight is plotted against time, with critical points such as shipment noted. The trick is to fire as the probability nears a peak and before wear-out sets in. Such a function for smaller operations consists of a moment's decision by the boss, based on his knowledge of the situation. Here a separate group of people requires inputs, training and co-ordination.

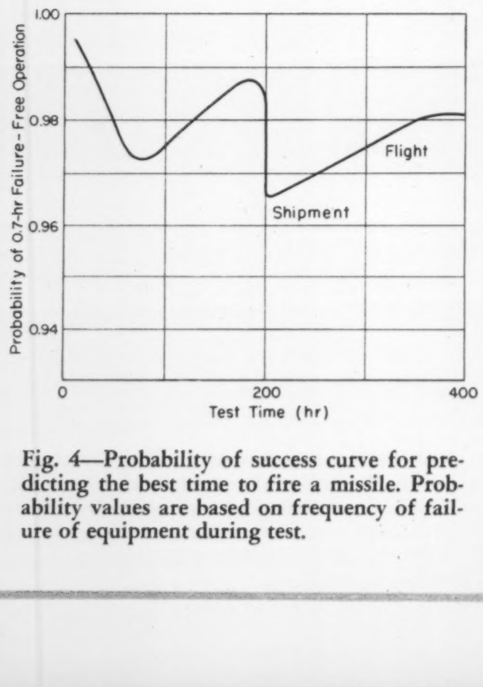


Fig. 4—Probability of success curve for predicting the best time to fire a missile. Probability values are based on frequency of failure of equipment during test.

**Investment in the Future:** Another facet of large systems is the great investment prior to the first real performance results. This forces a great resistance to innovation and yet a large system is likely to demand much innovation. The solution here is a series of partial and complete simulations of the eventual use, where test organizations do carefully engineered tests of sample, incomplete, and "breadboard" articles.

Again, testing of a product as it progresses is standard practice in all industries. The difference here lies in magnitude. The test must in many cases never be quite realistic. One can't test the actual consequences of color television or the effectiveness of a weapon until the development is long since over. This requires the formation of test organizations who are forever extrapolating toward tests they can't quite actually carry out.

The test engineer has in many ways a harder job than the man developing the article. In the case of guided missiles, the test engineer is rapidly becoming the key man. He has the problem of determining if a device will work for sure without working it.

### Organizing Large Engineering Projects

**Problems**

1. Complex lines of communication that must span various scientific disciplines and organizational barriers.
2. Large investment prior to first realistic test.
3. Difficult morale and motivation problems in technical personnel.

**Recommended Solutions**

1. Recognize and formalize across-lines coordination.
2. Train specialists in project direction and coordination.
3. Train the whole organization in a philosophy of large-system engineering.
4. Establish an appropriate set of specialized engineering groups.
5. Mechanize routine paper work.
6. Provide the best facilities possible.

**New Group Assignments:** These are but two examples of the specialized organizations coming into existence. Fig. 5 shows some more. Above the line of main stream effort are the more traditional specialized groups now common to most industry. Below the line are many of the newer groups becoming separate and performing functions that require co-ordination with project and line managers.

The specialized group opens the way to accomplishment not otherwise possible. But it further complicates the managerial problem and tends to force the development of specialists in project co-ordination.

## Personnel Problems and Solutions

All of these tendencies are very upsetting to the well-trained engineer, accustomed to individual work. When transplanted into a large system organization, he will find himself directed to disclose data before it is finished, change his direction for "political" considerations, compromise perfection of his product for the benefit of the whole, and otherwise act like an irresponsible cog in the wheel.

**Morale Problem:** Much of his concern can be eliminated or reduced by training and a clear-cut exposition of the problems and proposed solution. However, any way you look at it, as the organization grows, many highly skilled, inventive men are placed in a position of reduced control over the direction and planning of their own work. The morale problem therein is reflected in the general unhappiness of engineers as revealed in a recent study.

The solution to this problem is being tackled in two ways. First, engineers are being grown in the atmosphere of large system projects and hence satisfied with them. Second, physical facilities are being improved. The latter method provides a working environment that is both physical evidence of stature in the company and an efficient place to do creative work, thereby in some measure compensating for the loss due to increased size.

**Departmental Conflicts:** Another problem is underlined by a recent experience of a large industrial concern. This company found it had a sort of cold war raging between its engineering division

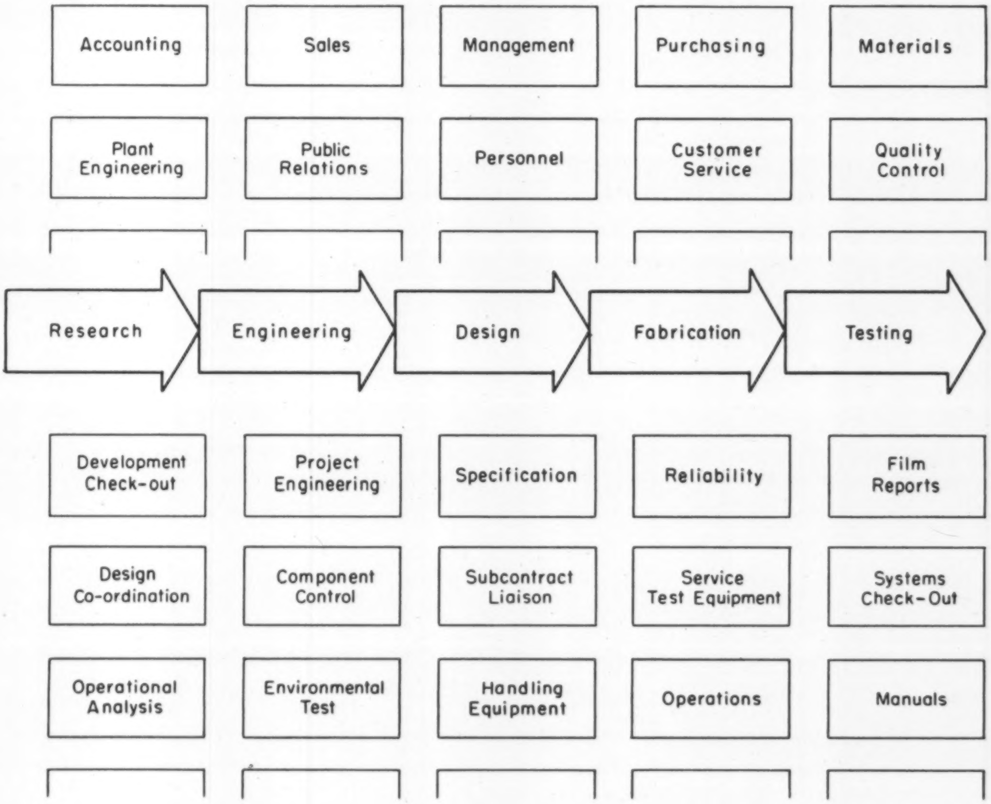

Accounting
Sales
Management
Purchasing
Materials
Plant Engineering
Public Relations
Personnel
Customer Service
Quality Control
Research
Engineering
Design
Fabrication
Testing
Development Check-out
Project Engineering
Specification
Reliability
Film Reports
Design Co-ordination
Component Control
Subcontract Liaison
Service Test Equipment
Systems Check-Out
Operational Analysis
Environmental Test
Handling Equipment
Operations
Manuals

Fig. 5—Development of specialized groups for engineering project organizations. Traditional groups are shown above main divisions of project effort; newer group functions are shown below.

and a "service" department. Management heard both sides of the story and determined that all leaders involved were competent and right. So, the conclusion reached was that the organization must be wrong.

The service in question was purchasing and the dissension was on a number of issues. Purchasing had many rules to follow aimed at reduction of cost and avoidance of legal entanglement. Engineering wished to allow the vendors some freedom and to work with vendors' engineering in true co-operative spirit, with corresponding violation of these rules. Purchasing wished to reduce overhead to a minimum, resulting in a constant backlog of orders and inability to tabulate nonroutine analyses of status at engineering's whim.

Engineering felt that to delay a project a few days was far more costly than any number of clerks, and to operate without having full data was sinful.

The solution being tried is to automatize the routine work. The process chosen (1) preserves the engineer's original description, thus eliminating clerical errors; and (2) provides such mechanized records that any report wanted is obtained with negligible clerical labor. If the plan is fully carried out, the labor saving will permit much more personalized attention of purchasing agents to engineers' problems and needs.

The mechanization of routine solves the clerical help problem, provides better information, and frees skilled personnel to work on the many special problems requiring their attention. It also impersonalizes a portion of the service organization, thereby to some extent removing the emotional stress of fundamental conflicts. It's a step that small services can take toward the automatic, prompt, consistent and friendly atmosphere carefully nurtured by public utilities.

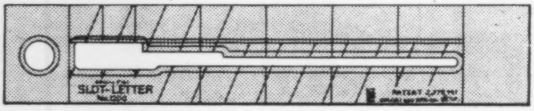
**Overall Approach:** Major problems faced by the organization that would engineer a series of large systems and their recommended solutions are summarized in *Organizing Large Engineering Projects.*

These may not be the best or even the right solutions but it is assured that solutions will be found. Large systems are being developed and permanent facilities for developing them are being founded. When these have matured they will provide the field of engineering and the country with a powerful force.

# Tips and Techniques

## *Ready-Made Lettering Template*

Lettering through a slot rather than on guide lines as described on Page 113 of the Oct. 18, 1956, issue of MACHINE DESIGN seems to be a good idea. In fact it's so good that the Dolgorukov Mfg. Co., 407 Fisher Bldg., Detroit 2, Mich., has been marketing a device very similar to that described for about 15 years. This should be good news for inexpert plastic whittlers who like the idea. The ready-made device incorporates reference lines for even letter spacing and a circular cutout for circling part numbers on drawings.

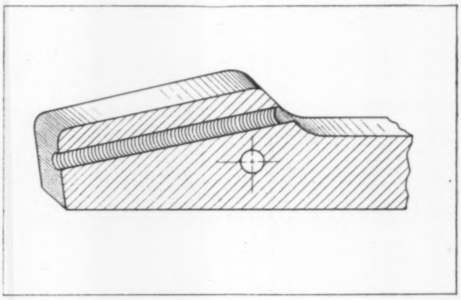


## *Saving Drafting Time*

Where a new part or model is only a minor variation from an existing one, complete redrawing to full size is expensive. If a small copy of the existing item is available—reduced photocopy, catalog page, etc.—the new item may be wholly or partly traced and changes noted or drawn. Often such prints will be available on 8½ by 11 in. or smaller sheets which will also reduce cost of prints made from the revised drawing.—JOHN W. HEALEY, *Cuyahoga Falls, O.*

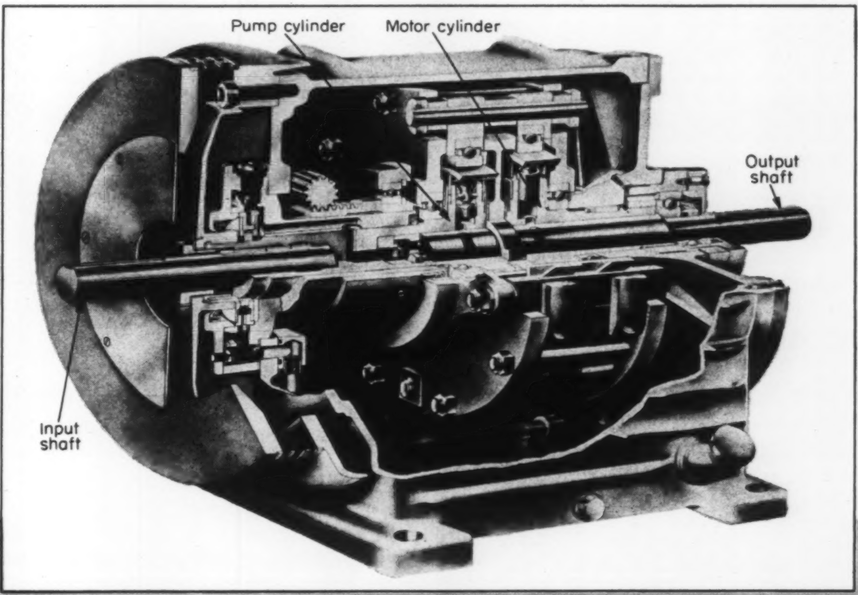
## *Improved Lead Holder*

Lead-holding action of a compass may be improved by running a 2-56 or 1-64 tap through the hole in which the lead is clamped. Very little tightening of the clamp screw will then hold the lead very tightly.—ERNST A. KREMEYER, *St. Joseph, Mich.*



**Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.**

# scanning the field for Ideas



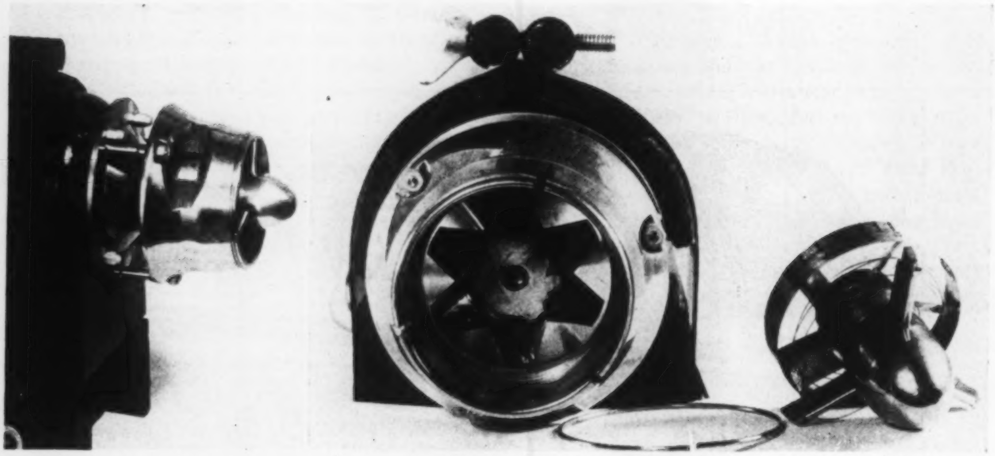
**ADJUSTABLE CONTROL OF OUTPUT SPEEDS** in a positive-displacement type hydraulic transmission is accomplished by simultaneously varying pump and motor stroke. In an infinitely variable unit developed by Carter Gears Ltd. (England), there is no oil flow at either zero or maximum output speed. Output speed is directly proportional to pump stroke which is maximum at maximum speed.

In construction, the transmission is composed of a multiple-piston input pump, a similar output motor unit, and an assembly for adjusting stroke of the pump and motor at any speed. The pump cylinder block is keyed to the input shaft whereas the motor cylinder block remains stationary. In the stroke-adjustment assembly are two eccentric elements in the form of ball-bearing races which are angularly displaced by 180 degrees and are connected by a web member to the output shaft.

Speed is adjusted by means of an external control shaft which mechanically moves the eccentric crank elements across the axis of the transmission. This action simultaneously increases pump stroke and decreases hydraulic motor stroke or vice versa. Thus at zero output speed, pump stroke is zero and motor stroke is maximum. At maximum output speed, pump stroke is maximum and motor stroke is zero. Oil flow is maximum at one-half of the maximum output speed.

# IDEAS

**ACCURATE MEASUREMENT OF SHAFT SPEEDS** without mechanical or electrical contact is accomplished through the novel application of an axial flow fan. In a speedmeter developed by Boas J. Popper of Kfar-Ata, Israel, the airstream from an axial flow fan is used to rotate the speed indicator which consists of shrouded guide-vane unit. Deflection of the guide vanes, which can be rotated 300 degrees against a spring, is proportional to the square of the angular velocity of the fan.



**SPIRAL-CURVE RECORDING OF DATA** on multiple-channel magnetic memory drums simplifies electrical circuit requirements for processing information in digital form. Employed in a medium-speed, digital computer developed at Northrop Aircraft Inc., the recording technique permits considerable reduction of computer size. Through the use of a moving pick-off head mechanism, it is possible to record on or read from 64 magnetic memory-drum channels with only two pick-off heads. The heads are mounted on a transverse carriage which is geared to make one full cycle up and down the face of the memory drum in approximately 2 seconds. Each head records or reads along a spiral curve as it moves up or down while the memory drum revolves at the rate of 1800 rpm. The mechanism reduces pick-off circuitry requirements to about 3 per cent of that which would be required if separate heads were used for each of 64 channels.

**Do you have a novel design idea for our other readers? You can receive ten dollars or more for each idea accepted for exclusive publication in this department. Send a short description plus drawings or photos to: "Scanning the Field for Ideas," MACHINE DESIGN, Penton Bldg., Cleveland 13, O.**

## Methods for analyzing and designing

# Pivoted-Shoe Radial Bearings

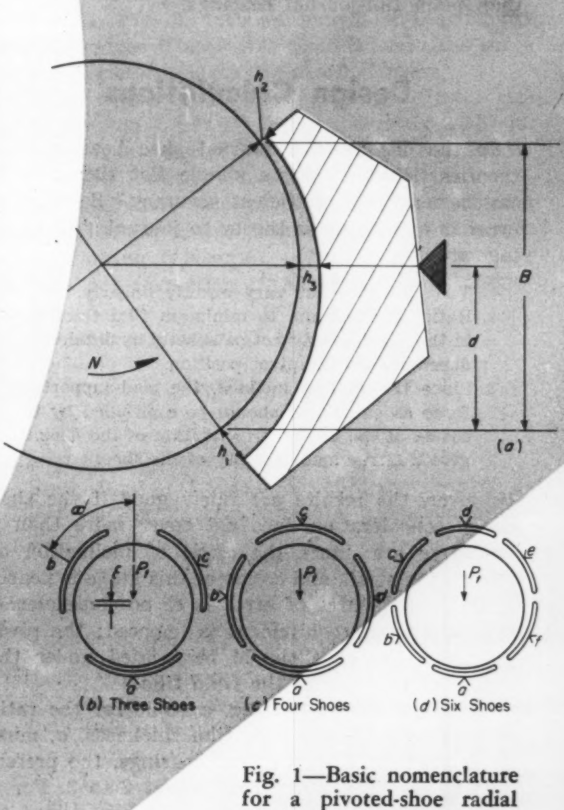
By Eugene J. Cattabiani
*Development Engineer*
*Atomic Equipment Dept.*
*Westinghouse Electric Corp.*
*Cheswick, Pa.*

**Bearings with pivoted shoes or pads have several important advantages over plain journal bearings: they are self-aligning within certain load limits, shaft whirl is virtually eliminated, and liquids containing abrasive particles are more easily handled. Practical methods for designing three, four and six-shoe bearings are detailed here.**

PIVOTED-SHOE or pivoted-pad radial bearings, Fig. 1, have several important advantages over plain journal bearings. Shaft whirl (oil film whirl or oil whip)[1] is almost completely eliminated, except at extremely light loads and high speeds. Pivoted-shoe bearings are inherently self-aligning, since the lubricant pressure is automatically "adjusted" by tilt of the shoe to compensate for moderate changes in load. Particles in suspension in the lubricant are quickly flushed out between the shoes; a full journal bearing has difficulty ridding itself of such particles.

The design study on which this article is based was aimed at the prevention of shaft whirl in canned motor-pumps. In these pumps, the radial bearings operate in a vertical position and are very lightly loaded. With a full journal bearing under these conditions, the shaft could conceivably "whirl," a condition in which the journal center rotates in an orbit about the center of the bearing. Excessive vibration then occurs and the load-carrying capacity of the bearing becomes so low that failure may result. Although shaft whirl has not created any failure to date, the lightly loaded conditions in canned motor-pump radial bearings do point to the possibility. The pivoted-shoe bearing is one answer to the potential problem. The self-aligning feature of the pivoted-shoe bearing also adds reliability, since water is the lubricant and film thicknesses are minute.

Pivoted-pad bearings have two principal disad-



(b) Three Shoes (c) Four Shoes (d) Six Shoes

Fig. 1—Basic nomenclature for a pivoted-shoe radial bearing, and variations in number of shoes which can be used.

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[1] References are tabulated at end of article.

**Nomenclature**

$a$ = Ratio of maximum to minimum film thickness, in./in.
= $h_1/h_2$
$B$ = Shoe chord length, in.
$C$ = Radial bearing clearance, in.
$C_c$ = Bearing support factor
$C_p$ = Bearing load factor
$d$ = Distance of pivot and center of pressure from inlet end along chord of shoe arc, in.
$h_1$ = Maximum film thickness, in.
$h_2$ = Minimum film thickness, in.
$h_3$ = Film thickness under pivot, in.
$L$ = Shoe axial length, in.
$N$ = Shaft speed, rpm
$P$ = Bearing shoe load, lb
$P_t$ = Total load capacity of bearing, lb
$Q$ = Side leakage correction factor
$U$ = Velocity of bearing surface, in. per second
$\alpha$ = Angle between load and shoe pivot, degrees
$\varepsilon$ = Eccentricity: radial distance between bearing and journal centers, in.
$\mu$ = Viscosity of lubricant, reyns

vantages: (1) for a given film thickness they have a lower load capacity than full journal bearings, except when film thicknesses are very small, and (2) they are more expensive to manufacture than plain full-journal bearings.

## Design Calculations

In the design of a journal shoe bearing, the theories developed for a simple flat tilting shoe can be used with sufficient accuracy.[2] Sources of error in applying this theory to journal shoe bearings are:

1. The gap does not vary exactly linearly.
2. Ratio of maximum to minimum film thickness in the bearing may not be exactly as decided on, depending on the pivot position.
3. Since the shoe is inclined, the load-supporting force as calculated should be multiplied by the cosine of the angle of inclination of the shoe to give the true load capacity of the shoe.

However, the results are fairly good if the shoe under consideration does not cover more than a 90-degree arc. Since the angle of inclination of the shoe is small, and cosine of this angle is nearly 1, the third source of error is of no consequence. One additional requirement is imposed: the pivot point for the shoe should be located under the center of pressure of the fluid film.

In design of the bearing, a value for the ratio of maximum to minimum film thickness, $a$, must be decided on. For practical bearings, the preferable values of $a$ range from about 2 to 3. For a particular set of conditions, $a$ can be selected to give minimum power loss, maximum load capacity or optimum conditions for any of the usual bearing criteria. However, minimum power loss and highest capacity cannot be achieved in the same design.

Once $a$ is decided, the load factor, $C_p$ and support factor $C_c$ can be evaluated:[2]

$$C_p = \frac{6}{(a-1)^2}\left[\ln a - \frac{2\,(a-1)}{a+1}\right] \tag{1}$$

$$C_c = \frac{1}{C_p}\,\frac{6}{(a-1)^2(a+1)}\,[a\,(a+2)\ln a - 2.5\,(a-1)^2 - 3\,(a-1)] \tag{2}$$

The bearing support factor from Equation 2 is used to determine location of the center of pressure, and consequently the pivot location,

$$d = BC_c \tag{3}$$

while the load supported by each shoe can be determined from

$$P = \frac{\mu U B^2 L}{h_2^2}\,C_p\,Q \tag{4}$$

The end leakage factor $Q$ can be determined from Fig. 2, and

$$U = \frac{\pi DN}{60}$$

The only variable left unspecified is $h_2$, the minimum film thickness at the outlet end of the shoe. The following analysis shows how to determine this film thickness.

From the geometry of a plane slider bearing,

$$\frac{h_3 - h_2}{h_1 - h_2} = \frac{(B-d)(h_1 - h_2)}{B} \tag{5}$$

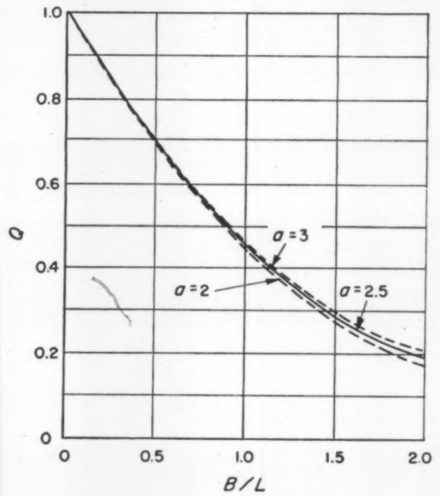

Fig. 2—Side-leakage factor, $Q$, for different bearing configurations, $B/L$, and film-thickness ratios, $a$ (Reference 2).

and, as already determined,

$$h_1 = a\,h_2 \tag{6}$$

Combining Equations 5 and 6,

$$h_3 = \frac{(B - d)\,a + d}{B}\,h_2 \tag{7}$$

Except for the inclination of the shoes, the tilting shoe bearing can be regarded as a species of journal bearing in which the film thickness at the pivot location $h_3$ is the same as that of a plain journal bearing of the same dimensions. Thus, from conventional analyses,

$$h_3 = C + \varepsilon \cos \alpha \tag{8}$$

Combining this equation with Equation 7,

$$h_2 = \frac{B}{(B - d)\,a + d}\,(C + \varepsilon \cos \alpha) \tag{9}$$

The minimum film thickness occurs when $\alpha =$ 180 degrees, so $\cos \alpha = -1$. In this case,

$$h_m = \frac{B}{(B - d)\,a + d}\,(C - \varepsilon) \tag{10}$$

Since the bearings in question are used as guide bearings, the load may act in any direction. When the load passes directly through the center of one shoe, the bearing has its lowest load-carrying ability.[3]

Under this condition, the film thicknesses and loads for a three-shoe bearing, Fig. 1*b*, would be worked out as follows:

$$h_{2a} = \frac{B}{(B - d)\,a + d}\,(C + \varepsilon \cos 180)$$

$$= \frac{B}{(B - d)\,a + d}\,(C - \varepsilon)$$

$$h_{2b} = h_{2c} = \frac{B}{(B - d)\,a + d}\,(C + \varepsilon \cos 60)$$

$$= \frac{B}{(B - d)\,a + d}\,(C + 0.5\,\varepsilon)$$

From Equation 10, however,

$$\varepsilon = C - \frac{(B - d)\,a + d}{B}\,h_m$$

Therefore,

$$h_{2a} = h_m \tag{11}$$

$$h_{2b} = h_{2c} = 1.5\,\frac{B}{(B - d)\,a + d}\,C - 0.5\,h_m \tag{12}$$

The total load on the journal is analyzed as

$$\begin{aligned} P_t &= P_a - P_b \cos 60 - P_c \cos 60 \\ &= P_a - 2\,P_b \cos 60 \\ &= P_a - P_b \end{aligned} \tag{13}$$

For a four-shoe bearing, Fig. 1*c*, following the same type of analysis,

$$h_{2a} = h_m \tag{14}$$

$$h_{2c} = 2\,\frac{B}{(B - d)\,a + d}\,C - h_m \tag{15}$$

$$P_t = P_a - P_c \tag{16}$$

For a six-shoe bearing, Fig. 1*d*, the comparable equations are:

$$h_{2a} = h_m \tag{17}$$

$$h_{2c} = h_{2e}$$

$$= 1.5\,\frac{B}{(B - d)\,a + d}\,C - 0.5\,h_m \tag{18}$$

$$h_{2d} = 2\,\frac{B}{(B - d)\,a + d}\,C - h_m \tag{19}$$

$$h_{2b} = h_{2f}$$

$$= 0.5\,\frac{B}{(B - d)\,a + d}\,C - 0.5\,h_m \tag{20}$$

$$P_t = P_a + P_b - P_c - P_d \tag{21}$$

## Practical Bearing Design

A pivoted shoe bearing has been designed as the lower bearing for the Westinghouse 4000-C canned motor pump. A three-shoe design was decided on, Fig. 3, with an individual bearing arc of 90 degrees. This leaves room between the shoes for a device to clamp the bearing insert.

Axial length of the bearing shoe to fit the motor pump is $L = 4.5$ in.; diameter is 3.375 in. Lubricant is water at 200 F for which $\mu = 3.84 \times 10^{-8}$ reyns. Rotational speed, $N = 3600$ rpm.

An optimum ratio of maximum to minimum film thickness, $a$, was decided on as 2.5. This sets the following values: $C_p = 0.158$ (Equation 1); $C_c = 0.589$ (Equation 2); and $h_1 = 2.5\,h_2$ (Equation 6).

The shoe arc covers 90 degrees, so

$$B = \frac{3.375}{2}\sqrt{2} = 2.39 \text{ in.}$$

$d = 1.41$ (Equation 3), and $h_3 = 1.615\,h_2$

Since $B/L = 2.39/4.5 = 0.531$-in., then $Q = 0.69$ from Fig. 2. Also, from the given conditions,

$$U = \frac{\pi\,(3.375)\,(3600)}{60} = 636 \text{ in./sec}$$

Therefore, the load on any shoe is, from Equation 4,

$$P = \frac{(3.84)\,(10^{-8})\,(636)\,(2.39)^2(4.5)\,(0.158)\,(0.69)}{h_2^{\,2}}$$

$$= \frac{68.44\,(10^{-6})}{h_2^{\,2}}$$

Minimum film thicknesses are, from Equations

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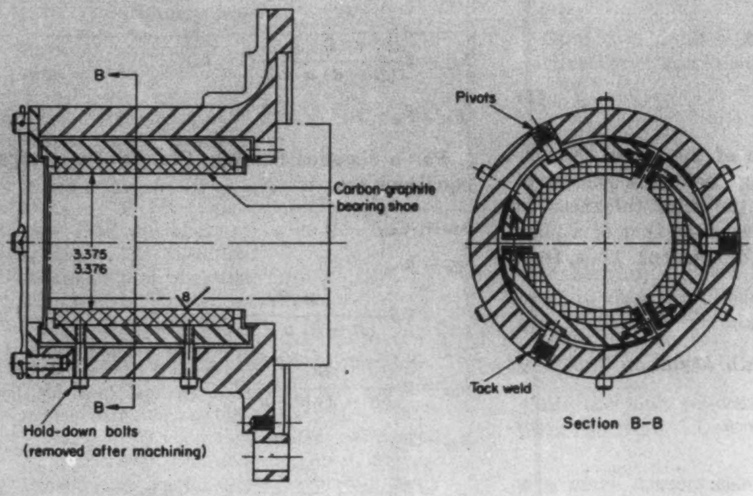
B
Pivots
Carbon-graphite bearing shoe
3.375
3.376
8
B
Hold-down bolts (removed after machining)
Tack weld
Section B-B

Fig. 3—Actual three-shoe bearing designed for the Westinghouse 4000-C canned motor-pump.

11 and 12,

$$h_{2a} = h_m$$

$$h_{2b} = h_{2c} = 0.93\ C - 0.5\ h_m$$

Total load capacity of the bearing is found from the previous three equations, and Equation 13:

$$P_t = P_a - P_b$$

$$= 68.44\ (10^{-6}) \left(\frac{1}{h_m{}^2} - \frac{1}{(0.93\ C - 0.5\ h_m)^2}\right)$$

In this bearing design, radial bearing clearance $C$ ranges from 0.003 to 0.004-in.

Bearing materials used, Fig. 3, are Graphitar No. 14 shoes (U. S. Graphite Co.) running against a journal of malcomized 17-4PH stainless steel (Armco Steel Corp.). The pivot has a cap with a minimum of ⅛-in. of Stellite No. 12 (Haynes Stellite Co.) for wear resistance. The rest of the assembly is all stainless steel.

The carbon-graphite segment in each shoe is compressed axially by shrinking it in the retainer and circumferentially by heating the assembly prior to fastening the end clips in place. Each shoe is then rigidly fastened to the bearing housing with four bolts by bolting down against 1/16-in. brass shims.

Shoe pivots are then tightened and locked in place with tack welds. The internal diameter is ground to the proper size and surface finish, and bolts and shims removed. The top bearing retainer is then bolted in place.

A bearing of this design has operated for over 1600 hours in a test loop with many starts and stops. Removed after this test period, the bearing was in near-perfect condition; it showed no wear and very little scoring.

**Operation Under Abrasive Conditions:** For slurries and similar "lubricants" containing abrasive particles, four or more shoes should probably be used. Materials might be solid Alundum shoes against a flame-sprayed Alundum or carbide journal. Then the bearing materials could be harder than the particles in suspension.

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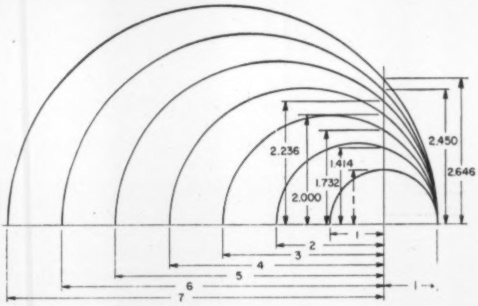
1. R. S. Sherwood—"How to Prevent Oil Film Whirl in Journal Bearings," MACHINE DESIGN, December, 1953, Page 163.
2. A. E. Norton—*Lubrication*, McGraw-Hill Book Co., Inc., New York, 1942, Pages 72-87 and 161.
3. John Boyd and A. A. Raimondi—"An Analysis of the Pivoted Pad Journal Bearing," *Mechanical Engineering*, May, 1953, Page 380.

# Tips and Techniques

## Graphical Square Roots

Lines equal in length to the square root of a number may be constructed by first drawing a semicircle equal in diameter to the number whose square root is to be found. Then erect a perpendicular to the diameter, one unit in from the circumference. Length of this perpendicular from diameter to point of intersection with the circumference is the square root of the diameter.—A. J. SINIBALDO, *Visking Corp., Chicago, Ill.*



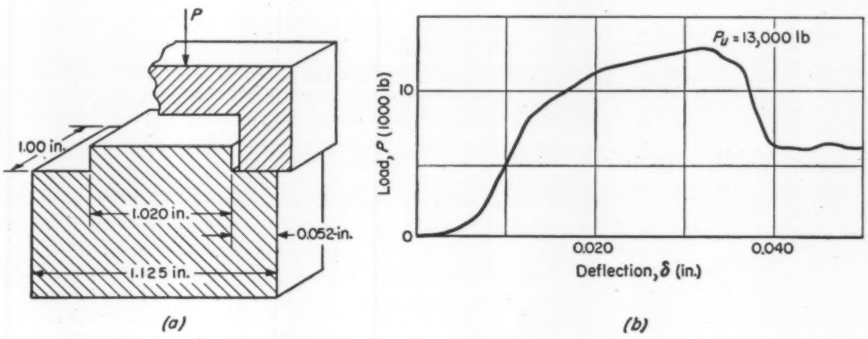


Fig. 1 — Straight groove wall or shoulder loaded by plane - faced sleeve showing, *a,* test assembly and, *b,* corresponding load - deflection diagram.

# *An analytical method for determining*

# Load Ratings of

# Retaining Ring Assemblies

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RETAINING or snap rings are designed to provide an artificial shoulder for locking or positioning components on shafts and in housing bores. For maximum resistance to axial thrust loads, rings are usually mounted in annular grooves although certain self-locking types permit application with ungrooved surfaces in light assemblies.

In the development of design data for groove-mounted ring assemblies, attempts have been made to establish load ratings not only for the rings themselves but also for the grooves in which they are seated. Conventional starting points for such analyses are usually two basic assumptions:

1. Ultimate thrust load to which a ring may be subjected depends upon its shear resistance; that is, shear strength of ring material times ring shear area.
2. Ultimate thrust load to which a groove may be subjected depends upon its compressive resistance; that is, compressive strength of groove material times area of groove wall.

For the first assumption, a safety factor of four is adequate in cases of repeated static loadings, as proved by tests and field experience. The second assumption, however, obviously includes an underestimation of groove strength since the reinforcing influence of the body of the shaft or housing is disregarded. Here, a relatively moderate safety

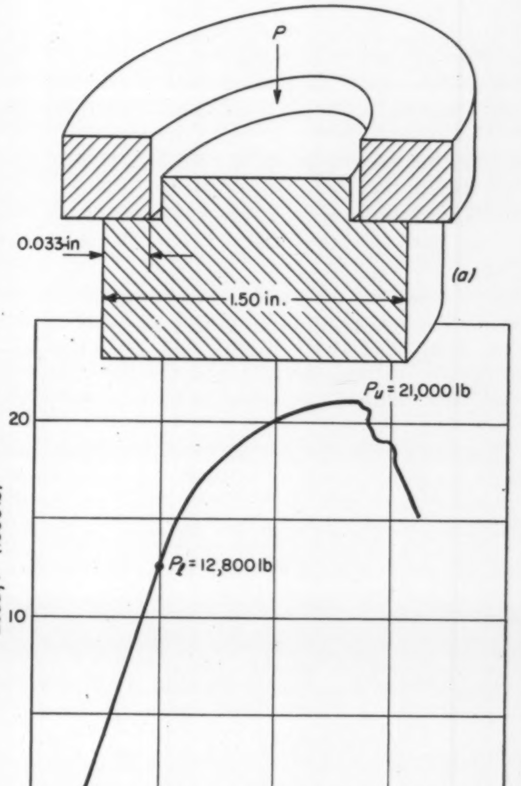

Fig. 2—Circular groove wall or shoulder loaded by plane-faced sleeve showing, *a,* test assembly and, *b,* corresponding load deflection diagram. Material is 2024-T4 aluminum.

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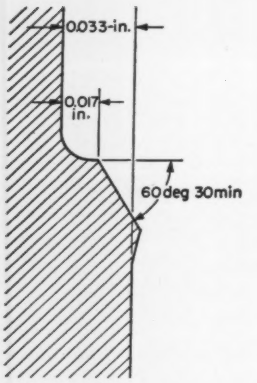

Fig. 3 — Magnified section profile of groove wall of test assembly in Fig. 2 after shear failure.

factor of three has been proposed for establishing permissible thrust load values for ring assemblies.

Degree of underestimation of groove strength inherent in the second assumption was recently measured by a series of tests. These tests have shown conclusively that the ultimate thrust capacity of a groove wall (that is, when it is totally deformed and partly sheared through) exceeds the value obtained from simplified calculations based on the foregoing assumption by at least 100 per cent.

Need for a more satisfactory approach to the problem of groove strength has prompted an investigation of the thrust resistance of ring assemblies under varying load conditions. Results of that investigation, including a new analytical method for determination of ring and groove load ratings, are reported in this article.

**Test Methods:** As a basis for analysis of groove characteristics, tests were performed under simplified conditions; that is, with the groove walls loaded directly with plane-faced machine parts. Test assemblies and corresponding load-deflection curves for typical straight and circular grooved-wall constructions are shown in Figs. 1 and 2, respectively.

The load-deflection curves for these assemblies, Figs. 1*b* and 2*b*, as well as those for full ring assemblies which will be discussed later, may be divided into three characteristic portions:

1. Initial deflection under moderate load to bring the parts to full grip with each other.
2. Load proportional deflection to a point that determines the so-called proportional limit load.
3. Rapidly increasing deflection to the breaking point which determines the ultimate thrust load, $P_u$, of the assembly.

As shown in Figs. 1*b* and 2*b*, test values of ultimate load $P_u$ for the two assemblies are 13,000 and 21,000 lb, respectively. These values are at least twice those obtained by simplified calculation methods based on the second assumption previously discussed.

**Groove Wall Behavior:** But the most relevant information offered by the tests was on the behavior of the groove wall under ultimate load. Failure of the groove wall would normally be expected to occur at the inner, relatively sharp-cornered, edge by cracks or flaws induced by high stress concentration. However, under ultimate load, the groove wall sheared through on surfaces inclined at a certain angle $\gamma$, with failure starting inside the groove wall but at varying distances from the inner edge. Fig. 3 shows a magnified section profile of a sheared wall portion of the circular groove test assembly, Fig. 2. Material is 2024-T4 aluminum. Shear angle $\gamma \approx 60$ deg.

Thus, the conclusion seems justified that the surfaces of least resistance in a groove wall or shoulder are shear or slip surfaces inclined at some angle with the wall surface. Many tests on full ring assemblies of different sizes have verified this conclusion.

**Groove Strength Analysis:** Consider, for analysis, the simplified assembly shown in Fig. 4. Basic assumptions for this case are: (1) deformation or

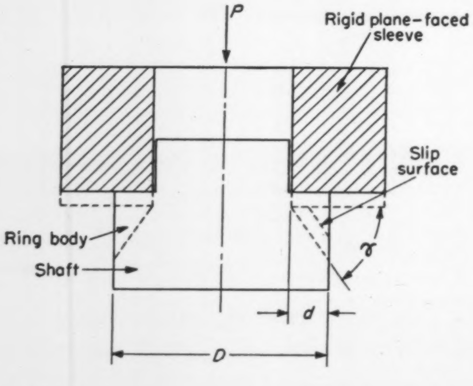

Fig. 4—Left — Simplified groove assembly for analysis of wall strength. Loading is accomplished through plane-faced sleeve.

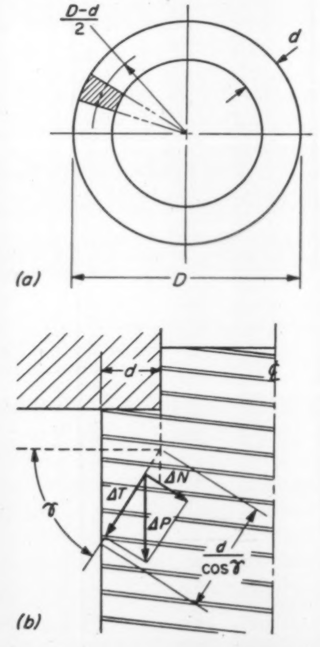

Fig. 5—Right—Basic relationships for analysis of groove wall element under load showing, *a*, plan view of groove wall or shoulder and, *b*, force diagram.

deflection of the groove wall is uniform, (2) probable distribution of specific pressure $p$ is constant, (3) deformation of the groove wall is caused mainly by the slipping of the material along (conical) surfaces inclined at a certain angle, $\gamma$, and (4) angle $\gamma$ depends on the internal friction along the slip surfaces.

If no internal friction existed, $\gamma$ would be 45 deg. But this angle, as proved by many tests, exceeds 45 deg considerably (Fig. 3) due to the reinforcing influence of the internal friction of the groove material.

From an analysis of forces acting on a groove wall element, Fig. 5, it can be shown that

$$p\ (\sin\gamma\cos\gamma - \mu\cos^2\gamma) = \tau \qquad (1)$$

where symbols are defined in the accompanying Nomenclature.

Two conclusions may be drawn from Equation 1 which relates the specific pressure exerted by the plane-faced sleeve against the groove wall and the shearing strength of the groove material:

1. Ultimate pressure that can be applied to the groove wall depends not only on the shear strength of the groove material but, to a large extent, also on the coefficient of internal friction.
2. Shear angle $\gamma$ is that angle for which the normal pressure $p$ is a minimum. That is, the expression, $\sin\gamma\cos\gamma - \mu\cos^2\gamma$, becomes a maximum.

From Equation 1, setting the first derivative of the expression in parentheses equal to zero and solving to find a maximum gives:

$$\mu = -\cot 2\gamma \qquad (2)$$

Thus, if either $\mu$ or $\gamma$ are known, the other unknown quantity can be readily calculated from Equation 2. For 2024-T4 aluminum, slip or shear angle of the groove construction shown in Fig. 4 is approximately 60 deg, Fig. 3. From Equation 2, then, the coefficient of internal friction is approximately 0.58.

Combining Equations 1 and 2 and solving for $P_u$ gives:

$$P_u = 2\tau d\pi D\tan\gamma \qquad (3)$$

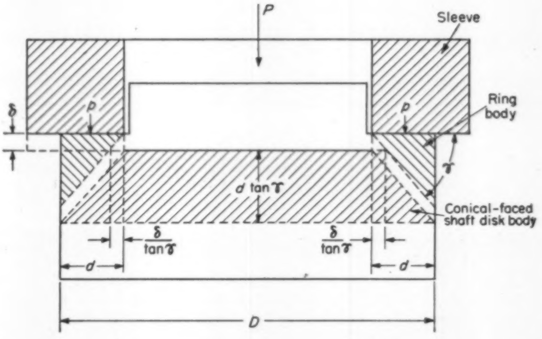
P
Sleeve
Ring body
δ
p
p
γ
d tan γ
Conical-faced shaft disk body
$\frac{\delta}{\tan\gamma}$
$\frac{\delta}{\tan\gamma}$
d
d
D

Fig. 6—Simplified groove assembly for analysis of deflection under load. Circular groove wall or shoulder is loaded by plane-faced sleeve and abutted by conical-faced shaft disk body. Cone angle is $\gamma$.

For the 2024-T4 aluminum groove construction, where $\gamma$ is approximately 60 deg, Equation 3 becomes:

$$P_u \approx 10dD\tau$$

If $\gamma = 45$ deg, $\tan\gamma = 1$ and, from Equation 2, $\mu = 0$. Thus, the ultimate thrust resistance of a groove wall or shoulder where there is no internal friction would be

$$P_u = 2dD\pi\tau$$

For example, in a groove construction with the dimensions shown in Fig. 2 where $\tau = 40{,}000$ psi (2024-T4 aluminum) and slip angle is 60 deg, $P_u = 10\ (0.33)\ (1.5)\ (40{,}000) = 20{,}000$ lb. This calculated result is quite close to the tested value of

## Nomenclature

$b_r$ = Average width of retaining ring section, in.
$D$ = Shaft diameter, in.
$D_n$ = Diameter of neutral axis of retaining ring, in.
$d$ = Radial width or depth of groove wall or shoulder, in.
$d_e$ = Effective groove width or depth, in.
$E$ = Modulus of elasticity of groove wall material, psi
$E_r$ = Modulus of elasticity of retaining ring material, psi
$G$ = Shear modulus of elasticity for groove wall material, psi
$h$ = Distance between points of application of thrust load and reaction force on retaining ring, in.
$\Delta N$ = Normal component at slip surface of axial load on groove wall element, lb
$P$ = Thrust load, lb
$\Delta P$ = Axial load on groove wall element, lb
$P_l$ = Proportional limit load on groove wall corresponding to yield strength in shear of groove material, lb
$P_u$ = Ultimate or maximum allowable load on groove wall at failure, lb
$p$ = Unit load or specific pressure on groove wall
$s_r$ = Bending stress in middle section of ring, psi
$\Delta T$ = Tangential component, along slip surface, of axial load on groove wall element, lb
$t$ = Thickness of retaining ring, in.
$\gamma$ = Shear angle of groove wall material, deg
$\delta$ = Groove wall deflection, in.
$\delta_m$ = Maximum groove wall deflection, in.
$\kappa$ = Yield strength in shear of groove wall material, psi
$\mu$ = Coefficient of internal friction for groove wall material
$\nu$ = Poisson's ratio
$\tau$ = Maximum shear strength of groove wall material, psi
$\phi$ = Angle of deflection of groove wall, deg

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21,000 lb (Fig. 2*b*).

When the thrust load is not increased up to the value determined by maximum shear strength of the material, but only up to the yield strength in shear, $\kappa$, it can be concluded that deflection is purely elastic because at no point on the groove wall is the yield strength of the material in shear exceeded. Also, the relationship of proportional limit load for the groove wall to ultimate load is given by the ratio, $\kappa/\tau$. Therefore, the expression for the proportional limit load in this specific case, Fig. 4, is

$$P_l = 2\kappa d\pi D \tan\gamma \tag{4}$$

For $\gamma = 60$ deg (2024-T4 aluminum), Equation 4 becomes

$$P_l \approx 10dD\kappa$$

For the assembly shown in Fig. 2, with $\kappa = 24{,}000$ psi (2024-T4 aluminum), $P_l = 12{,}000$ lb. This result agrees closely with the tested value, Fig. 2*b*, of $P_l = 12{,}800$ lb.

It should be mentioned that fracture of the groove wall under ultimate load does not necessarily start at the inner edge of the groove wall. It may, in fact, start at any point between the outer and inner groove wall edges because any of the possible slip surfaces are subjected to equal working stresses. But this has no bearing on the equations for ultimate or proportional limit load, much in the same manner as the case of a tensile test where it is irrelevant at which exact spot of its length the fracture of a tensile test specimen occurs.

As compared to load calculations based on Equations 3 and 4, a wide range of actual load values may be expected for the different specimens even of one random test sample. This variation results because the coefficient of internal friction and, therefore, the tangent of slip angle $\gamma$ may vary considerably from one test specimen to another, and even from one section of a groove wall to another in the same test specimen.

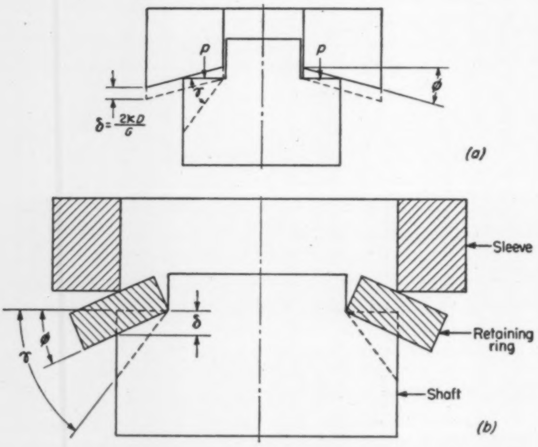

Fig. 7—Groove assemblies with basically similar load characteristics. At *a*, loading is accomplished by a sleeve with countersunk face; at *b*, load is transmitted to the groove wall through an intermediate retaining ring.

Moreover, it is of importance to recognize that the allowable thrust load of a groove wall as calculated from the simplifying assumption discussed initially, using a safety factor of 3, equals closely the allowable thrust load as calculated with Equation 3, using a safety factor of at least 6.

**Groove Wall Deflection:** The next problem to be analyzed for the circular groove assembly, Fig. 2*a*, is that of groove wall deflection under a limit load; that is, up to the point where proportionality between load and deflection ceases, Fig. 2*b*. As depicted in Fig. 6, it is assumed that a sleeve presses against the groove wall of depth *d* with thrust load *P*, creating uniform pressure *p*. The triangular ring body, limited by a conical slip surface inclined at angle $\gamma$, is abutted by the correspondingly conically faced disk body of the shaft.

Based on the volume of the groove wall displaced by the sleeve, an approximate expression for groove wall deflection can be derived:

$$\delta \approx \frac{\kappa}{E}(1-\nu)\, D \tan^2\gamma \tag{5}$$

Two conclusions, which have been confirmed by test results, may be drawn from this approximate deflection equation:

1. Deflections are independent of groove depth *d* because the thickness of the abutting shaft disk body increases proportionally with increasing groove depth.
2. Variations between minimum and maximum deflections in tested samples can be expected to be very large because of possible variations of internal friction and, consequently, of the square of the tangent of the slip angle.

Calculated deflection values, using Equation 5, show good correlation with test results. For example, in a circular groove assembly, Fig. 2, of 2024-T4 aluminum, deflection under test is $\delta = 0.007$-in. From Equation 5, $\delta = 24{,}000\ (10)^{-7}\ (0.7)\ (1.5)\ (1.732)^2 = 0.0075$-in.

A simplified form of Equation 5 is

$$\delta = \frac{\kappa D}{G} \tag{6}$$

which is based on $\gamma \approx 62$ deg and $\nu = 0.3$.

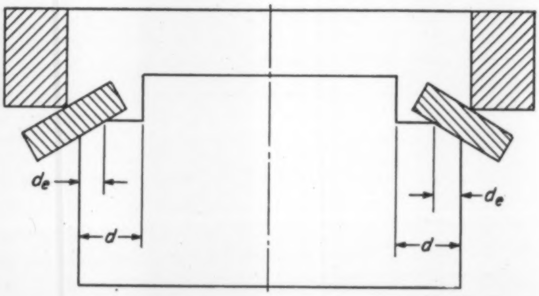

Fig. 8—Basic relationships for retaining ring assembly in which ring member is of relatively small thickness.

From Equation 5, for 2024-T4 aluminum with $\gamma = 60$ deg, $\delta = 0.005\ D$. From Equation 6, which corresponds to a slip angle of 62 deg, $\delta = 0.006\ D$. Thus, where the slip angle is approximately 60 deg as in the foregoing example, Equation 6 will give deflection values about 20 per cent greater than those obtained with Equation 5.

Design evaluation of retaining ring assemblies should be based on the upper limit of deflection and on the lower limit of load. For this reason, it is advisable to use Equation 6 for assemblies of the type shown in Fig. 2.

**Effect of Countersunk Sleeve Face:** Before investigating a full ring assembly, it is advantageous to consider a second intermediate fixture comprising a groove wall or shoulder loaded by a sleeve with countersunk face, Fig. 7*a*. The end configuration assumed here shows the groove wall deflected under angle $\phi$. Pressure distribution is triangular with zero pressure at the inner groove edge and linearly increasing pressure to the outer edge.

The same end configuration results for a groove wall on which load is applied through a sleeve acting on an intermediate retaining ring which dishes out under the thrust exerted on it by the machine part, Fig. 7*b*.

Thus it seems justified to assume that load equations developed for assemblies of the type shown in Fig. 7*a* apply also to full ring assemblies, Fig. 7*b*.

In Figs. 7*a* and *b*, failure of the groove wall under ultimate load again occurs along slip surfaces inclined at some angle $\gamma$. In both cases, as in the assembly shown in Fig. 2, ultimate and limit loads can be determined from Equations 3 and 4.

If the maximum deflection at the outer groove edge equals $\delta_m$ and the deflection at the inner groove edge equals zero, then mean deflection $\delta = \delta_m/2$. Thus, at limit load, $P_l$, deflections of the two assemblies shown in Figs. 7*a* and *b* are

$$\delta_m = 2\delta = \frac{2\kappa D}{G} \qquad (7)$$

For these two types of assemblies then, Equation 7 replaces Equation 6 for deflection calculations. If the groove wall material is again 2024-T4 aluminum, Equation 7 becomes $\delta = 0.012\ D$.

For a plane-faced rigid sleeve, Fig. 2, where mean and maximum deflection are the same, yield strength in shear is not exceeded at any point on the groove wall up to the proportional limit load. Therefore, the deflection falls practically into the elastic range.

This condition, however, is not true for the triangularly shaped deflection distribution (Fig. 7) under a corresponding proportional limit load, because near the outer edge of the groove wall the yield stress in shear is greatly exceeded. Even if the relationship between load and deflection up to the proportional limit load remains linear, near the outer edge of the groove wall there is a zone of plastic deformation which, upon release of load, results in a permanent set.

However, if only half of the calculated proportional limit load (Equation 4) is applied to the groove wall, with $\delta_m$ reduced correspondingly, and the yield strength in shear is not exceeded at the outer edge of the groove wall, plastic deformation and permanent set will be avoided.

The angle of countersink of the rigid sleeve for which the limit load $P_l$ is not exceeded is given by:

$$\phi = \tan^{-1}\left(\frac{2\kappa D}{Gd}\right) \qquad (8)$$

If $\phi$ is a small angle, then, in radian measure,

$$\phi \approx \frac{2\kappa D}{Gd} \qquad (9)$$

If the ratio of shaft or housing diameter to groove depth, $D/d$, is maintained approximately constant, the countersink angle $\phi$ will also remain constant and independent of the size of shaft or housing.

**Retaining Ring Stresses and Deflections:** If a re-

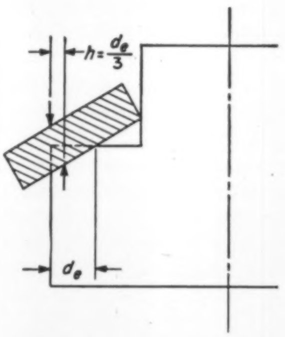

Fig. 9 — Section profile of dished-out retaining ring on deflected shoulder or groove wall.

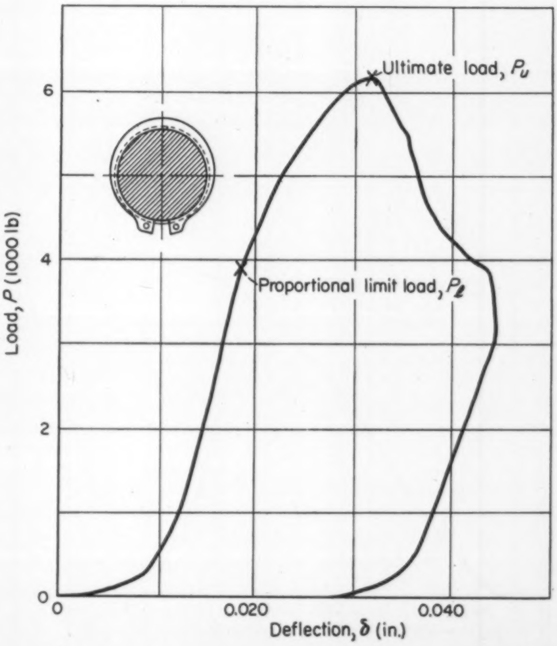

Fig. 10—Load-deflection diagram for an external retaining ring assembly mounted in standard groove. Shaft material is aluminum.

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taining ring has large thickness it acts like a rigid sleeve, Fig. 2. With decreasing ring thickness, the condition depicted in Fig. 7 is approached. Finally, as thickness decreases further, the deflected ring abuts only a portion, $d_e$, of full groove depth $d$, Fig. 8. The latter case will now be investigated.

Assumptions for this analysis are:

1. Section width of the ring is constant. (For rings of diminishing section width, the mean width can be substituted.)
2. Load is uniformly distributed along the outer ring edge while the reaction acts uniformly on the inner ring edge. If these forces do not act on the ring edges, as is usually the case, their value has to be multiplied by the ratio $b_r/h$.

Relationship between ring stresses and applied thrust load is

$$P = s_r t^2 \frac{b_r}{h} \tag{10}$$

Angle of deflection $\phi$ of ring body can be determined from

$$\sin \phi = \frac{s_r D_n}{E_r t} \tag{11}$$

and if $\phi$ is small,

$$\phi = \frac{s_r D_n}{E_r t} \tag{12}$$

in radian measure.

Fig. 2 shows that $D_n \approx D$. Thus, $\phi = S_r D/(E_r t)$. Combining Equations 10 and 12 and substituting $D$ for $D_n$ gives the load-deflection equation

$$P = \frac{\phi E_r t^3 b_r}{Dh} \tag{13}$$

**Ring Assemblies:** In the preceding discussion, load and deflection equations for rings and groove walls were derived independently. But when a ring is seated in its groove and loaded by a machine part, two conditions exist:

1. Deflection of the ring must equal deflection of the groove wall.
2. Thrust load on the ring is transmitted to the groove wall so that the reaction force at the groove wall must equal the thrust load.

These two conditions indicate that groove depth and ring thickness are more or less interdependent. If the active groove depth is smaller than a certain fraction of the ring thickness, the proportional limit load depends on this active groove depth.

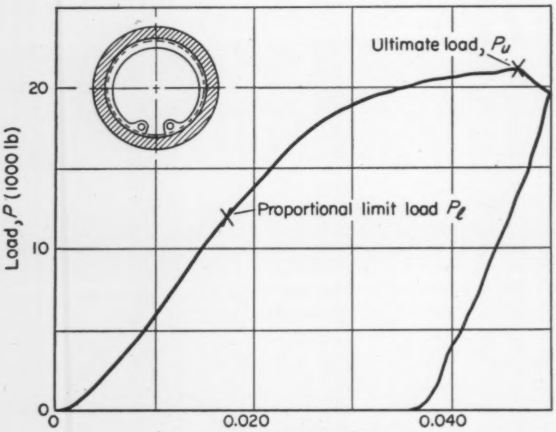

Fig. 11—Load-deflection diagram for an internal retaining ring assembly mounted in standard groove. Housing material is aluminum.

### Table 1—Proportional Limit Loads for Typical Retaining Ring Assemblies

| Nominal Size (in.) | Tested Load (lb) | Calculated Load (lb) | Difference (per cent) |
|---|---|---|---|
| **Internal Rings** | | | |
| ⅝ | 2,600 | 2,700 | + 4 |
| 1¼ | 11,600 | 10,500 | —10 |
| 2¾ | 37,200 | 41,600 | +12 |
| 4 | 72,800 | 73,200 | + 0.6 |
| **External Rings** | | | |
| 1½ | 13,800 | 12,600 | — 9 |
| 2 | 21,200 | 20,600 | — 3 |

But, if the active groove depth is larger than a certain fraction of the ring thickness, the proportional limit load depends on this fraction of ring thickness. This fraction of thickness, in turn, depends on the material of the ring and the material of the groove.

The ring, after deflection, may take a position in the groove, Fig. 9, so that it covers only a part, $d_e$, of the groove width. If pressure distribution on this effective groove width is triangular, $h = d_e/3$. Combining ring and groove deflection and load equations then,

$$d_e = t \sqrt[3]{\frac{E_r b_r}{GD \tan \gamma}} \tag{14}$$

Thus, effective groove width $d_e$ is a function of the ratios $E_r/G$ and $b_r/D$. For a typical commercial retaining ring design, values of $d_e$ for different materials are: steel, $d_e \approx 0.5t$; aluminum, $d_e \approx 0.7t$; and magnesium, $d_e \approx 0.83t$.

It is apparent that, to find the proportional limit load for the ring assembly, minimum groove depth must be compared with the effective groove depth and the smaller value chosen for $P_l$ calculations, Equation 4. The same holds true for ultimate load calculations with Equation 3.

Calculated and test values of proportional limit loads for several different ring assemblies of 2024-T4 aluminum are compared in Table 1. Load-deflection diagrams for typical external and internal ring assemblies are shown in Figs. 10 and 11. Results obtained by test and calculation verify the validity of the assumption that the internal friction of the groove wall material has a major quantitative influence on the load ratings of retaining ring assemblies.

# Hydraulic Servo Components—3

## . . . their effect on system performance

### Power Drives

- Valve-controlled cylinder
- Pump-controlled motor

By J. M. Nightingale
*Manchester, England*

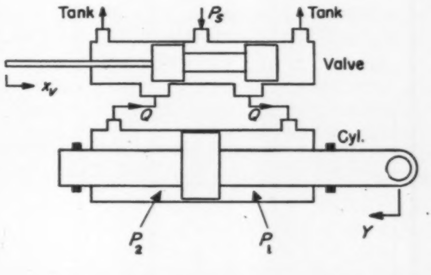

Fig. 21—Basic components of one type of power drive often used in hydraulic servo systems are a control valve and hydraulic cylinder. This article includes a mathematical analysis of the performance of such a system.

SINCE automatic-control or servo system performance is, in final analysis, the resultant of the performance of the various system components, an understanding of component characteristics is essential. This article will consider power drives, the muscles of a system. Other system components have been discussed in Parts 1 and 2.

In hydraulic servos, the power drive consists of a power source, a control valve or main amplifier and the servo motor. Function of the power drive is to produce the required output displacement and overcome any opposing loads. Because these loads are usually large, and power amplification always involves time lags, the power drive usually determines the performance of the servo as a whole.

Basic design considerations for two types of hydraulic drives will be considered. These are: (1) constant-pressure source plus flow-control valve plus cylinder-type displacement motor and (2) variable-delivery pump plus rotary-displacement motor. Occasionally, other combinations are used, for instance, a variable-delivery pump and a cylinder motor.

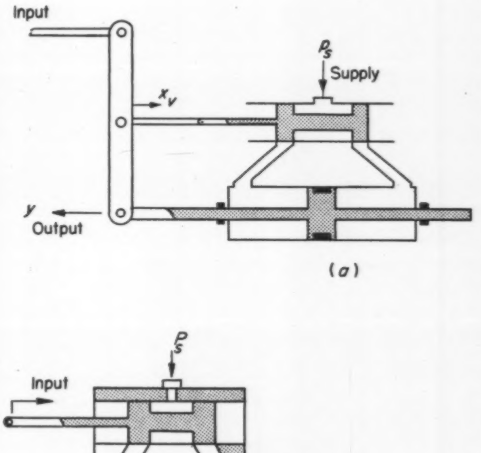

Fig. 22—A valve-cylinder servo system power drive requires a feedback system to close the loop. Either a lever differential, *a,* or virtual feedback resulting from a floating valve-cylinder body, *b,* are often used. Devices such as preamplifiers, transducers, etc., may also be included in the loop, but are omitted here. A block diagram of the power drive shown at *a* using lever differential feedback is shown at *c*.

**Valve-Controlled Cylinder:** Design parameters of this combination needed to satisfy the power requirements will be determined. Basic components of the system are shown in Fig. 21. In order to obtain explicit expressions for these design values, various simplifications must be made in the theoretical approach.

Flow from the supply line through the right-hand valve port is given by

$$Q = f(x_v)\sqrt{P_s - P_1} \qquad (15)$$

Similarly, flow from the cylinder through the left-hand valve port is

$$Q = f(x_v)\sqrt{P_2} \qquad (16)$$

If compressibility and leakage effects are neglected, these two flow rates must be equal. Equating them gives

$$P_1 + P_2 = P_s \qquad (17)$$

Since the differential pressure acting on the cylinder piston is

$$P_c = P_1 - P_2 \qquad (18)$$

Equations 17 and 18 may be combined to show that

$$P_s - P_1 = P_2 = \frac{P_s - P_c}{2} \qquad (19)$$

Substituting this value of $P_2$ in Equation 16,

$$Q = f(x_v)\sqrt{\frac{P_s - P_c}{2}} \qquad (20)$$

The function $f(x_v)$ describes the way in which the valve port is uncovered as the valve stroke $x_v$ is varied. Making each valve port a row of spaced holes permits approximation of a desired function. But for the moment it will be assumed that the relationship is linear. Then

$$Q = \frac{Cax_v}{X}\sqrt{\frac{P_s - P_c}{2}} \qquad (21)$$

where $C = 100$ if other quantities are in lb-in.-sec units.

This equation shows that flow varies not only with valve travel $x_v$, but also with pressure $P_c$ and hence with the cylinder load. Thus, in normal circumstances, dynamic output loading on the cylinder piston introduces a nonlinearity into the system equations which must be taken into consideration. However, for this analysis the output load will be considered constant. Flow is then proportional to valve displacement. Flow into the jack is given by Equation 8 ($Q = Ady/dt$). Then from Equations 8 and 21 it follows that the transfer function relating valve displacement to cylinder displacement is

$$\frac{y}{x_v}(s) = \frac{K_1}{s} \qquad (22)$$

where

$$K_1 = \frac{Ca}{AX}\sqrt{\frac{P_s - P_c}{2}}$$

In order to complete the servo the loop must be closed. Often, this will include other components such as preamplifiers, transducers and so on. In many cases, however, the loop contains only the valve and cylinder, and is closed either by a lever differential, Fig. 22*a*, or by virtual feedback, Fig. 22*b*. This type of closed-loop system is a servo in itself, but it is sometimes used as a preamplifier in a more complicated system.

Other system components may be represented by a scalar gain $K_2$. Note that for the system shown in Fig. 22*b*, $K_2 = 1$; while in Fig. 22*a*, $K_2$ depends only on the lever ratios. In these cases the approximate theory is reliable. It should be noted, however, that time lags in other components approaching that of the power drive may make this approach inaccurate.

Loop transfer function of the system, Fig. 22*c*, is

$$Y_0(s) = \frac{K_1 K_2}{s} \qquad (23)$$

The overall transfer function is, therefore,

$$Y_c(s) = \frac{1}{1 + Ts} \qquad (24)$$

where $T = 1/K_1K_2$.

In any specific application, system pressure $P_s$, cylinder stroke $L$, maximum cylinder load $F$ and certain operating times would probably be known. Design quantities to be obtained would then be cylinder piston area $A$, working pressure $P_c$, pump delivery $Q_s$, valve travel $X$ and valve port area $a$.

Power delivered to the cylinder is proportional to

## Nomenclature

$A$ = Effective cylinder piston area
$a$ = Total exposed valve port area, corresponding to $x_v = X$
$C$ = Constant
$F$ = Maximum cylinder load
$f(x_v)$ = Function describing how valve port area varies with $x_v$
$K_1, K_2$ = Gain constants
$L$ = Cylinder stroke
$L_p$ = Maximum pump control lever displacement
$N$ = Angular speed
$P_c$ = Differential cylinder pressure
$P_s$ = System supply pressure
$P_1$ = Pressure on inlet side of cylinder
$P_2$ = Pressure on outlet side of cylinder
$Q, Q_2, Q_n$ = Flow rates
$s$ = Laplace operator
$V_p$ = Pump displacement per revolution
$V_m$ = Motor displacement per revolution
$X$ = Maximum valve travel from neutral
$x_p$ = Pump control lever displacement
$x_v$ = Valve displacement from neutral
$Y_c(s)$ = Overall transfer function
$Y_o(s)$ = Loop transfer function
$y$ = Cylinder displacement from neutral
$(y/x_v)(s)$ = Transfer function
$\theta_i$ = Input displacement
$\theta_o$ = Output displacement
$\omega_b$ = Frequency bandwidth
$\omega_c$ = Frequency limit for accurate response

$P_c\sqrt{P_s - P_c}$ and is maximum when $P_c = 2/3\ P_s$. Therefore, maximum operating pressure should be two-thirds of the supply pressure, since maximum power is needed at full load to get the best possible performance. This fixes the effective piston area, which is obtained from

$$A = \frac{3F}{2\,P_s} \tag{25}$$

This figure for maximum pressure is satisfactory for another reason. If a higher operating pressure were chosen, performance at high loads would be very sluggish, since the valve flow would saturate and the motor stall.

Although Equation 24 shows the unit to be linear, this is so only while the valve is not fully open. There is an error $E = X/K_2$, above which the output velocity remains constant, since the full valve port area is exposed. Normally $E$ is a small fraction of the total output travel, which is the piston stroke $L$. Therefore, the response to an input step function of amplitude $L$, takes the form shown in Fig. 23. Over most of the stroke the valve is fully open and the output velocity constant. But as soon as the error is reduced to $E$, the valve begins to close and the output velocity decreases exponentially to zero.

Time for total stroke is given approximately by

$$T_0 = T_s + 2\,T \tag{26}$$

Substituting from Equations 22 and 24 for $T$ gives

$$T_0 = \frac{AL}{Q_s}\left(1 + \frac{X}{K^2L}\right) = \frac{AL}{Q_s}\left(1 + \frac{E}{L}\right) \tag{27}$$

where $Q_s$, the saturated flow from the valve, is

$$Q_s = Ca\sqrt{\frac{P_s - P_c}{2}} \tag{28}$$

Total time, $T_o$, varies with the output load. It is generally specified for the no-load condition as one of the design requirements. In this case it is

$$T_n = \frac{3\,FL}{2\,CaP\sqrt{\dfrac{P_s}{2}}} \tag{29}$$

provided $E/L$ is small.

In the full-load case, operating time is a minimum when $P_c = 2/3\ P_s$, and is equal to $\sqrt{3}\ T_n$. Therefore, the valve port area is

$$a = \frac{0.02\,FL}{T_n(P_s)^{3/2}} \tag{30}$$

when all quantities are in lb-in.-sec units.

Maximum flow demanded from the supply occurs under no-load, and is

$$Q_n = \frac{3\,FL}{2\,P_s\,T_n} \tag{31}$$

All the required parameters have now been determined except the valve stroke $X$. This limits the region within which the system is completely linear. The approximate frequency response bandwidth within this zone is given by

$$\omega_b = \frac{K_2\,L}{T_n\,X} \tag{32}$$

Thus for signals of approximate amplitude $E = X/K_2$, and for frequencies up to $\omega_b$, the output is a fairly faithful reproduction of the input. For any greater input signal of magnitude $\theta_i$, frequency response is limited by flow saturation of the valve. Accurate response can be obtained up to a frequency

$$\omega_c = \frac{L}{|\theta_i|T_n} \tag{33}$$

Above this frequency the response is not only attenuated, but is also distorted due to the nonlinear

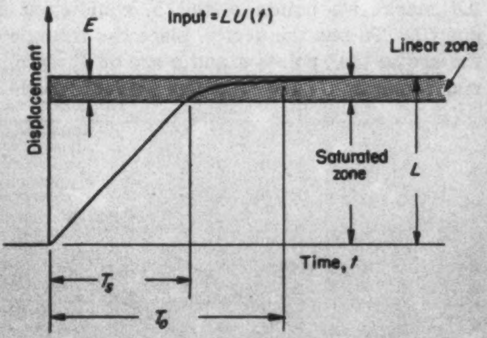

Fig. 23—Despite indications that the valve-cylinder power drive is linear, this is true only when the valve is not fully open. When the valve is fully open, output velocity is constant, due to saturation. This curve shows response to step function input of amplitude L.

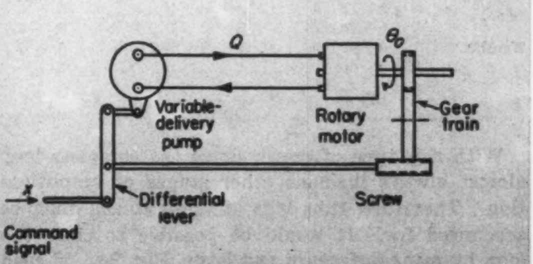

Fig. 24—A variable-delivery hydraulic pump and a fixed displacement rotary hydraulic motor are often used as the power drive in a servo system. Occasionally, other combinations such as a variable-displacement pump and a cylinder may be used. However, they are less common than this combination. A gear and lever system may be used to provide feedback in such a system.

XUM

effect of saturation. Typical values of $\omega_b$ and $K_2$ result in the ratio $X/L$ being about 1/20.

Substituting for the unknown parameters in terms of the known in Equation 24 gives the following expression for the time constant of the overall response:

$$T = \frac{3\,FE}{Q_s P_s} \tag{34}$$

In other words, the time constant is proportional to the output force, and width of the linear zone, and is inversely proportional to the power supplied by the source. This shows the penalty which must be paid.

Assuming that $P_s = 3000$ psi, $F = 4000$ lb, $L = 2.0$ in., $T_n = 0.25$ sec and $\omega_b = 80$ radians per sec for the system shown in Fig. 22*b*, where $K_2 = 1$, unknown parameters can be obtained from Equations 25, 30, 31 and 32. They are: $A = 2$ sq in., $a = 0.0039$ sq in., $Q_n = 16$ cu in. per sec, and $X = 0.1$ in. Time constant is, at no load, $T = 0.0125$ sec.

The overall response function is approximately

$$\frac{\theta_0}{\theta_i}(s) = \frac{1}{1 + 0.0125s}$$

This analysis is only a rough approximation of dynamic system behavior when there is considerable variation in output loading. However, when output loads are comparatively small, this method offers sufficient accuracy.

**Pump-Controlled Motor:** Basic components are shown in Fig. 24. The flow equations, neglecting compressibility and leakage for pump and motor, respectively, are

$$Q = \left(\frac{NV_p}{60L_p}\right) x_p \tag{35}$$

$$\theta(s) = \frac{1}{2\pi V_m} \frac{Q(s)}{s} \tag{36}$$

Combining these shows that the relation between motor rotation and pump lever displacement is

$$\frac{\theta}{x_p}(s) = \frac{K_1}{s} \tag{37}$$

where

$$K_1 = \frac{V_p}{V_m}\left(\frac{N}{120\,\pi L_p}\right)$$

With this type of power drive the complete loop almost always includes other stages of amplification. Therefore, time lags of these stages must be accounted for. It would be possible to close the loop by means of gears and lever, Fig. 24. If such a sysem is used, the overall transfer function is

$$\frac{\theta_0}{\theta_i}(s) = \frac{1}{1 + Ts} \tag{38}$$

where

$$T = \frac{V_m}{V_p}\left(\frac{120\,\pi L_p}{NK_2}\right)$$

and $K_2$ = the feedback system constant. This is very similar to the result obtained for the relay. However, this also is a rather oversimplified picture of the behavior of these units. Effects of compressibility and leakage in the pump, motor and circuit seriously impair performance. Other components also have characteristics which affect the system, for instance, backlash in the gears, and time lags in the preamplification stages. A future article will analyze in some detail more complex hydraulic servos built up of the units considered in this article.

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3. "Evaluating Servo System Performance—Part 1" July 26, 1956
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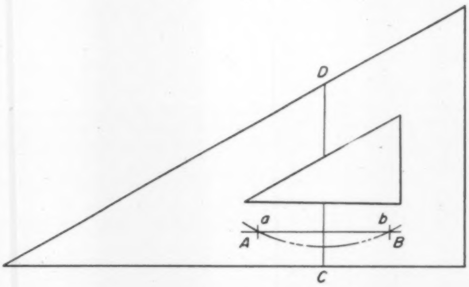
# Tips and Techniques

## *Locating Arc Centers*

A most used triangle can be easily converted into a device for locating centers of unknown arcs. Two lines *AB* and *CD* are scribed on the triangle at right angles to each other as shown. On line *AB* mark two points *a* and *b,* equidistant from line *CD.* To use the device, place the triangle over the arc so that points *a* and *b* are on the arc, then mark points *C* and *D.* Shift the triangle and repeat the process. Now join the points to make two intersecting straight lines. The point of intersection of the lines is the center of the arc.—PETER DITORO, *New York, N. Y.*



# Selecting Plastic Laminates and Vulcanized Fiber

WITH so many basic engineering materials now available, the task of choosing the right material is increasingly difficult. This problem is further complicated by the fact that similar materials may offer a wide variety of grades and characteristics. Two such materials are vulcanized fiber and laminated plastics. A selection chart, Table 1, can be extremely useful in choosing the proper grade of these materials for a particular application. Information for this table was supplied by R. F. Bogart, application engineer, National Vulcanized Fibre Co.

Vulcanized fiber is converted cotton with a tough, dense structure. A low cost material, it has: (1) excellent mechanical and good dielectric strength, (2) unique arc expulsion properties, (3) excellent machining and forming qualities. Vulcanized fiber is manufactured in many grades and forms with varying degrees of hardness, flexibility, resilience, drawing, forming, and punching qualities. These properties may be modified to meet new and specific conditions, needs and uses. In addition to the three grades of fiber listed in Table 1, there are many other special grades of this material.

Laminated plastics are thermosetting high-pressure laminates composed of various base materials and thermosetting resins. Fibrous materials, such as paper, cotton fabric, nylon, asbestos, glass fabric, cotton and glass mats are first impregnated with phenolic, melamine, polyester, epoxy or silicone resins and then bonded under high pressure to form a hard, compact infusible material. The laminated sheet is a lightweight material that combines exceptional toughness and moisture resistance with excellent electrical properties.

**Table 1—Properties of Laminated Plastics and Vulcanized Fiber**

| | Laminated Plastics (NEMA Grades) | | | | | | | | | | | | | | | | | | | | | | Vulcanized Fiber | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | X | P | PC | XX | XXP | XXX | XXXP | C | CE | L | LE | A | AA | N-1 | G-1 | G-3 | G-5 | G-6 | G-7 | G-8 | G-10 | GPO-1 | Comm'l. | Bone | Elect. Ins. |
| **General Information** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Base material | Kraft paper | Paper | Paper | Paper | Paper | Paper | Paper | Cot fabric | Cot fabric | Cot fabric | Cot fabric | Asb paper | Asb fabric | Nylon cloth | Glass fabric | Glass fabric | Glass fabric | Glass fabric | Glass fabric | Glass mat | Glass cloth | Glass mat | Cot paper | Cot paper | Cot paper |
| Type of resin | Phenolic | Phenolic | Phenolic | Phenolic | Phenolic | Phenolic | Phenolic | Phenol | Phenolic | Phenolic | Phenolic | Phenolic | Phenolic | Phenolic | Phenolic | Phenolic | Melamine | Silicone | Silicone | Melamine | Epoxy | Polyester | | | |
| AIEE insulation class | A | A | A | A | A | A | A | A | A | A | A | A | A | A | B | B | B | H | H | B | B | B | A | A | A |
| Comparative price | 0.7 | 0.8 | 0.8 | 1.0 | 1.0 | 1.1 | 1.2 | 1.4 | 1.4 | 1.7 | 1.7 | 1.1 | 2.7 | 3.7 | 2.9 | 2.7 | 2.4 | 6.7 | 6.7 | 1.8 | 3.7 | 0.9 | .4 | .4 | .4 |
| **Electrical Properties** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dielectric strength perpendicular to laminations (G=500 v/mil for $\frac{1}{16}$" mat'l.) | E | G | G | E | E | G | E | P | G | P | G | F | P | G | F | E | G | F | F | F | E | F | F | F | F |
| Dielectric strength, parallel to laminations (G=50 kv) | P | G | P | G | E | E | E | P | G | P | G | P | P | E | P | F | F | G | G | G | G | G | G | G | G |
| Dielectric losses | P | F | P | G | G | E | E | P | F | P | F | P | P | G | G | G | G | E | E | G | E | F | P | P | P |
| Insulation resistance | P | F | P | F | G | G | E | P | P | P | P | P | P | E | P | F | F | F | G | P | E | P | P | P | P |
| Arc resistance | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | P | E | E | E | E | F | G | E | E | E |
| Electrical stability (Humid conditions) | P | F | F | G | G | E | E | P | G | P | G | F | P | E | F | F | G | E | E | G | E | G | P | P | P |
| **Mechanical Properties** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tensile strength (G=15,000 psi) | G | F | P | G | F | F | G | F | F | F | F | F | F | P | F | E | E | G | E | G | E | G | P | F | F |
| Flexural strength (G=20,000 psi) | G | F | P | F | F | F | G | G | G | G | G | G | G | F | E | E | E | G | E | G | E | G | P | F | P |
| Compressive strength (G=30,000 psi) | G | F | F | G | F | G | F | G | G | G | G | E | E | P | E | E | E | E | E | E | E | E | G | E | G |
| Impact strength (G=1.0 lb-ft) | G | F | F | F | F | F | F | G | G | G | G | G | G | G | E | E | E | E | E | E | E | E | G | G | E |
| Bond strength | G | F | P | G | F | G | F | E | E | E | E | F | E | G | G | G | E | G | P | E | E | G | G | G | G |
| **Physical Properties** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Water absorption | P | F | F | G | G | E | E | F | G | F | G | F | P | E | F | F | G | E | E | F | E | G | P | P | P |
| Dimensional stability (humid conditions) | P | F | F | G | G | E | E | F | G | F | G | F | P | E | F | F | G | E | E | F | E | G | P | P | P |
| Heat resistance | F | F | P | G | F | G | F | F | G | F | G | G | G | P | G | G | G | E | E | G | G | G | P | P | P |
| **Chemical Properties** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Acid resistance | F | F | F | F | F | G | G | F | G | F | G | F | F | G | F | F | P | G | G | F | G | G | P | P | P |
| Alkali resistance | P | P | P | P | P | P | P | P | P | P | F | P | P | F | P | P | G | G | G | G | G | F | P | P | P |
| Organic solvent resistance | F | P | P | G | F | E | F | G | G | G | G | G | G | G | G | G | G | P | P | G | G | G | E | E | E |
| **Fabricating Properties** | | | | | | | | | | | | | | | | | | | | | | | | | |
| Machining qualities | F | F | F | G | G | G | G | E | E | E | E | F | F | E | P | P | P | P | P | P | P | P | E | E | E |
| Punching qualities | F | E | E | F | G | P | G | G | F | E | F | F | F | E | F | F | F | F | F | F | G | F | E | E | E |

Code: E=Excellent, G=Good, F=Fair, P=Poor

# *Materials and Techniques for*
# Metal-to-Metal Adhesives

A DESIGN technique of rapidly growing importance is metal-to-metal adhesive bonding. High-strength phenolic elastomers, vinyl-phenolics and epoxy-resin adhesives are being used to an increasing extent for the structural joining of aluminum, brass, magnesium, steel, stainless steel, titanium and copper. High-strength adhesives allow the engineer to design stronger, more eye-appealing, more fatigue-resistant joints with thinner, lighter metals. In assemblies of thin sheets, the bond strength of the adhesive often exceeds that of the metal itself.

This article considers the factors involved in the selection of adhesives, the general types of adhesives available to the designer, and some important factors in structural bonding. It also gives design considerations by which adhesives can be employed most effectively in metal joints, and representative applications of the technique. Properties of adhesives are summarized in Table 1.

## Selecting Adhesives

The important matter of selecting the right adhesive for each type of service is not a simple procedure. There is a great variety of adhesive products, and there is little standardization of their properties. Many users have resorted to writing their own performance specifications for procurement purposes. Others rely on specifications issued by government agencies. For most users, it is largely a process of evaluating several likely ad-

Table 1—Properties of Structural Adhesives

| | | Phenolic Elastomers | Vinyl Phenolics | Modified Epoxies: Room-Temperature Cured | Modified Epoxies: Heat Cured |
|---|---|---|---|---|---|
| **Shear Strengths at Various Temperatures** | Room temperature | 3000-4200 psi | 2500-5000 psi | 2500-4200 psi | 3000-5000 psi |
| | −65 F | 3500-4500 psi | 2000-3000 psi | 350-2500 psi | 1300-5000 psi |
| | 180 F | 1500-2800 psi | 800-4000 psi | 180-900 psi | 2600-5000 psi |
| | 250 F | 500-2500 psi | 100-1800 psi | — | 800-3600 psi |
| | 300 F | 400-2200 psi | 100-1200 psi | — | 450-3200 psi |
| | 350 F | 300-1700 psi | 100-500 psi | — | 200-1200 psi |
| **Physical Properties** | Flexibility | Excellent | Fair | Poor | Poor |
| | Room temperature creep and dead load strength | Good | Excellent | Excellent | Excellent |
| | Elevated temperature creep and dead load strength | Good | Good to limiting temperature | Poor | Good to limiting temperature |
| | Peel strength | Excellent | Fair | Poor | Poor |
| **Resistance to:** | Water | Excellent | Excellent | Fair | Excellent |
| | 100 per cent humidity | Excellent | Excellent | Fair | Excellent |
| | Salt spray | Excellent | Excellent | Poor | Excellent |
| | Oils | Excellent | Excellent | Excellent | Excellent |
| | Glycols | Excellent | Excellent | Good | Good |
| | Fuels | Excellent | Excellent | Excellent | Excellent |
| **Curing Procedure** | Cure temperature | 300-400 F | 250-350 F | 70-90 F | 200-350 F |
| | Cure pressure | 25-200 psi | 50-200 psi | Contact | Contact |
| | Cure time | 30-240 minutes | 30-120 minutes | 1-7 days | 60-90 minutes |

# *Structural Bonding with*

**By Sydney A. Hanks,** *Commercial Development Engineer*
*Adhesives and Coatings Div.*
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hesives against their known or projected requirements.

Applications should be studied to determine which properties and conditions are most important and limiting. In many cases two or more adhesives should be considered. Sample bonds should then be made and exposed to actual or simulated service conditions, and tested to determine actual bond strengths.

Parts to be bonded should be designed to take fullest advantage of the desired properties in selected adhesives. Adhesives seldom display their best properties when substituted directly for other fastenings. In the final selection of an adhesive, the engineer must consider end product properties, material costs, labor, capital expenditure for jigs and bonding equipment, and other factors which may affect the production and sale of products.

An adhesive joint derives its strength from using a larger contact area than joints of other types. Ideally, the whole joint is stressed if it is properly designed. Enough faying surface area must be designed into the joint to produce the required strength. If it is not possible to design for the best joint geometry, then an adhesive should be selected which performs best under the type of stress to be encountered. The adhesive that produces the strongest bond in tensile or shear will not necessarily produce the highest strength in peel.

In tensile or shear loading, the more rigid adhesive offers the greatest strength. However, if the joint will be required to flex or will be subjected to vibration or shock loads, then some compromise in ultimate strength must be made to provide a degree of resiliency to withstand the dynamic loading.

Peel-loaded joints are stronger when the adhesive has some elasticity. A brittle adhesive fractures readily and the joint fails progressively as stress is applied. Elastic adhesives are superior in peel because, in stretching under stress, they tend to widen the line along the load carrying edge. This distributes load over a greater area.

Greatly differing coefficients of expansion of dis-

## Advantages of Adhesive Joints

1. **Adhesives make it possible to join dissimilar metals with a minimum of bimetallic corrosion and also minimize corrosion from entrapment of moisture between surfaces. Adhesive acts as a continuous barrier between the two metals.**
2. **Continuous bonds produced by adhesives distribute stress loads evenly over entire joined areas. This eliminates local stress concentrations, produces joints of greater strength and rigidity than those made with separate fastenings and permits the use of lighter gage metals. These factors allow the design engineer to lower costs and weight and at the same time increase joint strength and rigidity.**
3. **Adhesive-bonded joints have good fatigue resistance. This is due to the stress distributing characteristics of adhesives and the ability of most adhesives to absorb or at least dampen vibration and shock. In many cases, adhesive-bonded metal joints have up to 10 times the fatigue resistance of riveted joints.**
4. **Adhesive bonding provides continuous contact between mating metal surfaces, thus sealing as well as bonding. This eliminates time and cost of separate sealing operations and permits the sealing of joints where it might not otherwise be possible. A good metal-to-metal bond is usually impervious to both liquids and gases. Many adhesives also act as electrical insulation.**
5. **Adhesive-joined metals form smooth, protrusion-free joints. This improves aerodynamics of exterior surfaces, enhances appearance, aids styling and eliminates gaps, bulges and external projections.**
6. **Adhesives maintain soundness of structural members. Holes for insertion of fasteners and countersinking to maintain a flush surface are unnecessary. Adhesives also eliminate excessive heat needed in welding or brazing operations that may tend to neutralize previous heat treatment.**

XUM

similar metals can present a problem, particularly if the adhesive to be used is not sufficiently elastic. A brittle adhesive develops great internal stresses as changes in temperature occur. These stresses can become great enough to destroy the bond itself or cause warping in the assembly.

Some adhesives will take great loads of short duration, but fail progressively when stressed under conditions of dead loads. Such adhesives slowly creep when constantly stressed for long periods of time. Rigid adhesives are better for dead load conditions.

Service conditions also narrow the choice of adhesive. Service temperature range is one of these factors. Many metal-to-metal adhesives will perform at low temperatures in the vicinity of −65 F. At the other extreme, 180 F is a common limit. The modified epoxies and phenolic-elastomer adhesives maintain appreciable strength up to service temperatures of 350 F. Much work is being done today to force the limit upward to keep pace with advanced aircraft design. Some modified epoxy-resin and vinyl-phenolic adhesives have room temperature shear strengths up to 5000 psi, although 3500 psi is a more representative figure for commercially available products.

Exposure to solvents, chemicals, fuels and other deteriorating media are often a part of service requirements. Metal-to-metal adhesives with resistance to most solvents and chemicals are available. Resistance to all media cannot be found in any one adhesive. Some are completely inert;

## Typical Structural Adhesive Applications

Honeycomb sandwich construction is an excellent example of new designs made possible through the use of adhesives. Sandwich construction consists of a lightweight core, sandwiched between two relatively tough, thin skins of metal. Cores consist of thin metal foils (or resin-reinforced paper or glass fabric), constructed in a cellular pattern resembling honeycomb. Such core constructions are sawed "across the grain" into sheets of desired thickness. Adhesives are used in the assembly of core materials and in the attachment of skins to the cores.

The light metals, aluminum and magnesium, can now be joined more strongly with adhesives than by any other method. The general advantages of adhesive joints apply particularly to light-metal joints in aircraft. In one case, helicopter blades had an average service life of 90 hours when assembled with rivets. Adoption of adhesive construction boosted the life expectancy to 1200 hours by improving the vibration resistance in the thin trailing edge of the blades.

Aircraft applications also take advantage of the excellent fatigue resistance of metal-to-metal adhesives. The importance of fatigue strength is recognized in Military Specification MIL-A-5090B which states that joints must remain intact after 10 million cycles under a fluctuating load from 0 to 600 psi. Several commercially available adhesives greatly exceed this figure today.

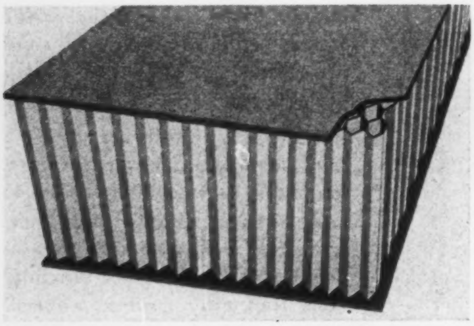
European aircraft manufacturers use metal-to-metal bonding adhesives extensively for attaching skin, making spars, webs and other heavy members more economically.

Phenolic-elastomeric resin type adhesives were used in the construction of B-36 wing panels. Some U.S. aircraft make use of adhesive bonding in load-carrying structures.

New elastomeric thermosetting adhesive films are used in bonding aluminum leading and trailing edges of helicopter rotor blades and are also used in bonding the trailing edges of aluminum aircraft wings. These adhesive films are also used in bonding aluminum to aluminum and the assembly of other metal-to-metal parts as primary and secondary structural components of aircraft missiles. Examples of such structures are compartment bulkheads, floors, skin, rudder and aileron members.

Phenolic elastomeric film adhesives are also used for structurally sealing integral aircraft fuel tanks and other closed systems.

Phenolic-elastomeric, vinyl-phenolics and epoxy



Honeycomb Sandwich Construction

Film Holder Has Adhesive-Joined Plates

and others are not affected seriously enough to impair their usefulness.

## Types of High Strength Adhesives

Adhesives are not really new engineering developments. Animal, fish and vegetable glues, hydraulic-setting cements and natural asphaltums were used before recorded history. Adhesive progress, however, has been slow until very recent times because designs were such that adhesives carried little, if any, load. Also, at least one of the adherents was usually porous to allow escape of solvents.

Developments in the last few years in polymer chemistry and the commercialization of many new resins have greatly increased the selection of raw materials available for metal-to-metal adhesives. These new materials make it possible to formulate adhesives with load-bearing ability. By varying the selection of thermosetting and themoplastic resins, elastomers and fillers, adhesive properties of flexibility, heat and cold resistance, exposure resistance, shear strength, dead-load strength and peel strength can be greatly modified. Three general types of adhesives are commercially available today that will produce high-strength structural bonds. They are the phenolic-modified elastomers,

resin adhesives are used to seal and bond guided missile components—skin to stiffeners and fins, for example—wherever high bond strength in the 300-350 F range is needed.

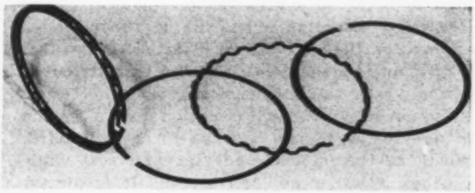
As rapidly as designs and tests can be completed, more aircraft structures and components will be joined and assembled with adhesives. As service history is accumulated, engineers are becoming more confident of adhesive-bonded structures.

An oil-resistant phenolic elastomeric adhesive provides a fast, easy method of joining anodized aluminum plates in a film holder at Graflex, Inc. The adhesive is sprayed on flat aluminum septum plates. The plates are then bonded to an aluminum core. The joining of the septums to the core was originally tried by spot welding but this method caused poor appearance and the aluminum was somewhat difficult to spot weld.

Metal-to-metal adhesives solved a problem at Muskegon Piston Ring Co. by allowing complex shapes to be fabricated that would probably be impossible with conventional methods. A spacer and two rails of oil rings are joined with a phenolic elastomeric rubber-based type adhesive to prevent separation during handling. In operation, the rings must separate into three component parts, each operating independently. When installed in an engine, the engine oil dissolves the adhesive, permitting the parts of the ring to perform unhindered. The adhesive is removed from the system with the first oil change.

One manufacturer uses an oil-resistant high-strength adhesive in the manufacture of automatic transmissions for motor busses. A carbon steel ring is joined by adhesive bonding to the machined surface of the torque converter housing. The adhesive also acts as a sealer against torque converter oil pressure. Operating temperature of the oil ranges from between 180 F to 220 F.

In the refrigeration industry, high-strength epoxy resin adhesives and phenolic modified elastomers are used to bond cooling coils to evaporators of home freezers. These adhesives are also used for bonding coils or tubing to fins of radiators used for dissipating heat.



Auto Engine Oil Rings: Components and Adhesive-Joined Assembly

Adhesive Sprayed on Film Holder Plates

Installation of Adhesive-Joined Oil Rings the phenolic-modified vinyls and the epoxy-resin-based compounds. Each type offers certain advantages over the other two.

**Phenolic-Modified Elastomers:** High strength adhesives of the phenolic-modified-elastomer type have good adhesion to most metal and usually offer good flexibility, vibration absorption and peel strength. They have excellent resistance to fuels, lubricants, humidity and salt spray. This type adhesive is characterized by a rather flat, slowly descending curve, Fig. 1, when shear strength is plotted against service temperature. This type adhesive has a tendency to creep at elevated temperatures when subjected to dead loads that are in excess of about two-thirds of its shear strength. Room-temperature shear strengths are in the range of 3000 to 4200 psi in aluminum-to-aluminum joints.

Modified elastomers are particularly suited to the joining of thin metal sheets to themselves or to supporting structures. They are excellent for bonding and sealing integral fuel tanks and other liquid reservoirs. They may be used in honeycomb construction if a special effort is made to physically form a fillet between the honeycomb and the skin. Modified elastomers do not self-fillet. Phenolic-elastomeric adhesives are available in solvent

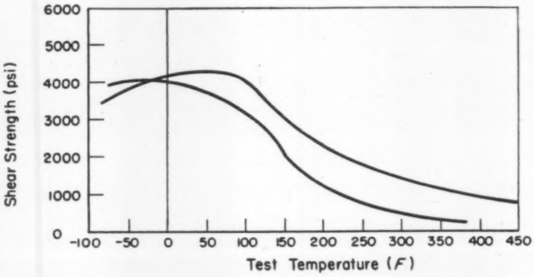


Fig. 1—Variation of shear strength with temperature of nitrile phenolic adhesive bonds between 2024-T3 Alclad aluminum sheets.

## Designing for Metal-to-Metal Bonding Adhesives

Greatest strength is obtained in a metal-to-metal adhesive joint if the maximum amount of bonded area is put to work. The first fundamental of design for adhesive use is to plan all metal joints so that the geometry is most favorable to maximum strength.

In a joint loaded entirely in tension, the forces are in a direction perpendicular to the plane of the joint. The tensile force is distributed uniformly over the entire area. The entire joint is under stress at the same moment and all of the adhesive is at work at one time. It is a simple matter to calculate the load carried by any particular area in the joint.

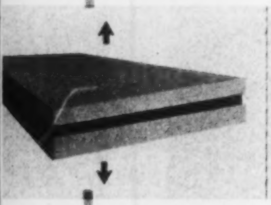
A similar situation exists in the shear loaded joint, except that the stress direction is parallel to the plane of the joint. Stress is distributed uniformly over the entire joint.

A somewhat different situation exists in the cleavage loaded joint. As the force is applied, one side of the joint is under great stress while the other is under no load at all. It is almost as if one side of the joint were hinged. Theoretically, the unit stress increases from zero on one side to infinity on the other. Therefore, not all of the adhesive in the joint is contributing its share of strength. The cleavage-loaded joint cannot be as strong as a joint of the same area under tensile or shear loading.

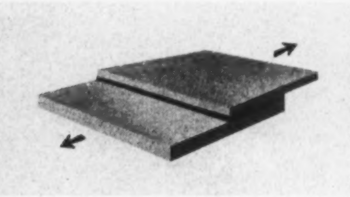
The least favorable situation of all, from the standpoint of strength, is the joint which is stressed in peel. In this case, even less of the adhesive contributes to strength than in the cleavage joint. All of the stress is concentrated along a fine line at the very edge of the joint. Most of the adhesive in the joint is under no load at all. This small portion of the total bonded area will support only a fraction of the load that the whole joint area could if the load were applied differently.

Rarely, if ever, is an ideal joint achieved in which the stresses are entirely pure tensile, shear, cleavage or peel. In practice, there is usually a combination of several different types of stresses and each joint must be carefully planned if maximum strength is an important factor.

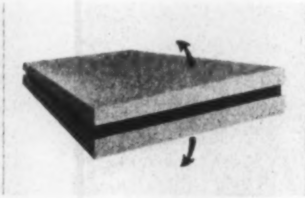
**Tensile Loading:** In the case where metal joints are designed for tensile loading, two things can happen while the joint is under high stress. Either the forces do not stay in a direction perpendicular to the plane of the adherends, or one or both of the metal adherends, if thin, may tend to bend or twist. In either case, it is possible for the forces to resolve themselves into cleavage or even peel.



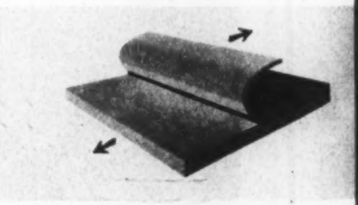
Tensile Loading



Shear Loading



Cleavage Loading



Peel Loading

solutions or as films.

Phenolic-elastomeric compounds are a one-part thermosetting resin and thermoplastic rubber-base type adhesive. Elastomers such as nitrile and neoprene rubber are modified by the addition of thermosetting resins to form load-bearing compounds. These compounds vary considerably from one to another depending on the type and amount of reinforcers contained in the formulation. The higher strength products usually contain vulcanizing agents for the rubbers as well as activators for the resins. Recommended curing procedure ranges from 300 to 400 F for 30 to 240 minutes under a pressure of 25 to 200 psi, depending on the adhesive used and properties required.

**Modified Vinyl Phenolics:** High-strength modified vinyl phenolics have good adhesion to most metals and offer good shear strengths at room temperatures. Shear strengths are in the range of 2500 to 5000 psi on aluminum. Strength drops off rapidly as the thermoplastic temperature of the vinyl is approached, Fig. 2. This type adhesive has fair peel strength (superior to expoxies but poorer than phenolic-modified elastomers) and fair resistance to vibration and shock.

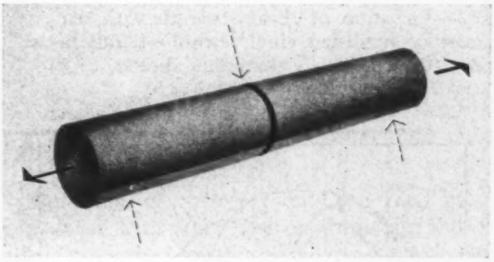
The modified vinyl phenolics have excellent resistance to water, 100 per cent humidity, salt spray, hydraulic fluid, engine oil and fuel. They have been used extensively in metal-to-metal honeycomb sandwich construction. Although they do not self-fillet, procedures have been worked out for applying the compounds to both honeycomb and faces, resulting in good honeycomb bonds. These compounds are available as solvent solutions or as supported films. Films offer the advantages of easy application, uniform thickness and reduced waste.

Vinyl resins such as polyvinyl-butyral and polyvinyl-formal are modified with phenolic resins to

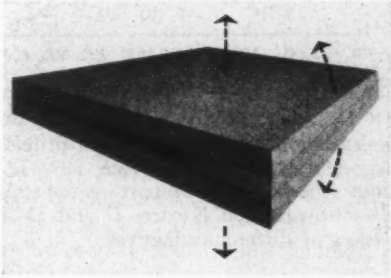
Adhesives do not lend themselves well to a butt joint design. In the case where two metal rods are butt joined with an adhesive, any bending of the rods can, through leverage, exert tremendous cleavage forces on the joint and can easily cause failure.

Tensile-loaded joints must be made with great care to insure uniform strength over the whole area. Any area of low strength, particularly if located near an edge, can induce a condition resembling cleavage and invite rapid failure.

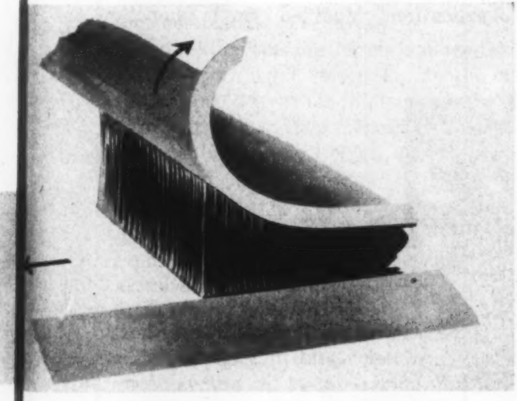
**Shear Loading:** The forces acting on a shear-loaded joint are not simple. If the metal adherends are completely rigid, an element of cleavage is induced as stress is applied. If the metal adherends are thin enough, they will bend slightly under load until the adhesive bond alignment is in better conformance with the direction of pull. As the stress is increased the metal deforms. The edges are then subjected to some peel stress and are more susceptible to failure.



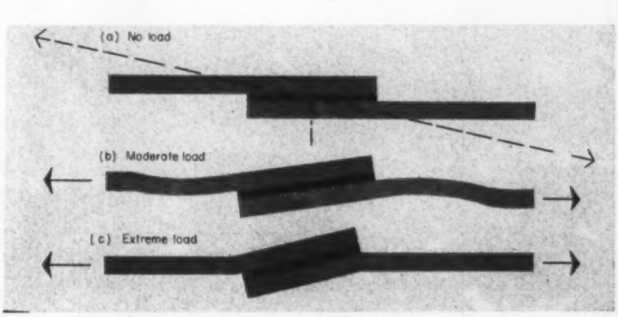
Forces Acting on Butt-Joined Rods



Effect of Weak Area in a Tensile-Loaded Joint



Detail of Peel Loading



Shear Bond under Increasing Load

form low-strength bonds by application of small amounts of heat and pressure. By increasing the cure time and temperature, the vinyls and phenolics can be made to crosslink and form new molecules with much higher heat resistance. Depending on the vinyl phenolic type adhesive used and properties required, curing ranges from 250 to 350 F for 30 to 120 minutes under a pressure of 50 to 200 psi are suggested.

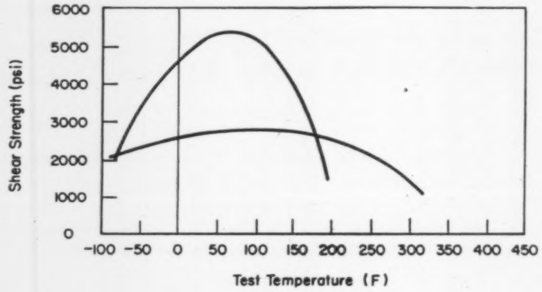


Fig. 2—Variation of shear strength with temperature of modified vinyl phenolic bonds between 2024-T3 Alclad aluminum sheets.

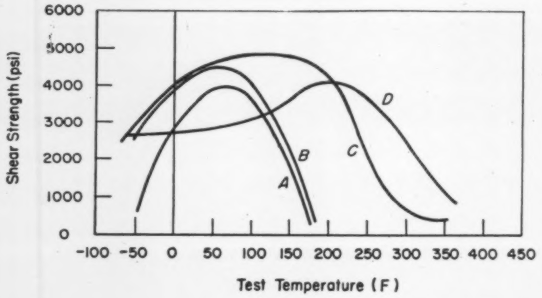


Fig. 3—Variation of shear strength with temperature of epoxy-adhesive bonds between 2024-T3 Alclad aluminum sheets: *A*—two-part room-temperature cure; *B*—two-part 200 F cure; *C* and *D*—one-part 350 F cures of different adhesives.

**Epoxy Resin Adhesives:** Most epoxy-resin adhesives offer a combination of high room-temperature strength with good load-bearing properties. These adhesives are usually quite brittle, have poor peel strength and some have poor shock resistance. They have excellent honeycomb filleting properties and exceptional adhesion to metal surfaces.

Most epoxy-resin based adhesives are two-part products (resin and activator) which when mixed together, will react and cure chemically even at room temperature.

Adhesives made from epoxy resins display a fairly uniform family of curves when shear strengths are plotted against service temperatures, Fig. 3. Each has a very definite temperature beyond which strength falls off rapidly. Room-temperature-cured specimens, usually cured with amines, lose strength very rapidly at 150 F and above. A 30-minute cure at 200 F raises the 180 F strength values considerably. To obtain strengths at elevated temperatures, epoxies are usually cured with acid anhydrides, diamides, dibasic acids, or phenolic resins at temperatures above 300 F. For applications where elevated-temperature resistance and resistance to salt spray and humidity are important, heat-curing epoxies should be carefully selected.

## Factors in Structural Bonding

**Cleaning:** Proper cleaning of the metals to be bonded is one of the most important parts of bonding operations. The best adhesive will produce poor results when bonded to an unclean surface. In most cases, maximum results can only be attained when the surfaces are absolutely free of dirt, grease, oxides and other foreign materials. Surface coatings such as paints and primers, other than specific adhesive primers, can cause a weak link in metal to metal bonds. A degreasing operation followed by an acid etch or an electrolytic treatment is usually necessary to obtain best results.

**Adhesive Application:** Modified vinyl phenolic

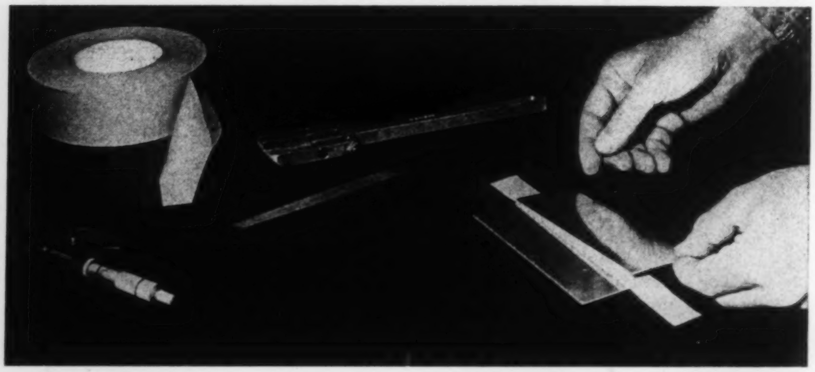


Fig. 4—High strength adhesive films are easily applied and have constant thickness. They are laid in place and bonded under heat and pressure.

and phenolic-elastomeric adhesives may be applied as films or as solutions. The epoxies are applied as 100 per cent nonvolatile liquids.

Adhesive films are usually laid in place either on the cleaned surface or over an adhesive primer that has been applied to the clean surface and thoroughly dried, Fig. 4. The 100 per cent nonvolatile liquids are usually knife-coated, brushed or applied with a notched trowel.

Solvent solutions may be brushed, sprayed, roll-coated or knife-coated. Solvents must then be allowed to evaporate completely before bonds are assembled. In some cases, force-dries at temperatures of 150 to 225 F are necessary to insure complete solvent removal.

**Bonding:** The use of structural adhesives may require jigs, fixtures, ovens, autoclaves or presses for assembling and proper application of heat and pressure during the curing cycle.

The bonding operation usually requires at least contact pressure, even during a room-temperature cure. Parts must be held in place while the adhesive sets. Pressures should be applied evenly to all parts of the bond area by jigs, fixtures or hydraulic or vacuum presses. Where heat and higher pressures are needed for curing, jigs and fixtures may be placed in ovens or autoclaves, or both heat and pressure may be applied through a heated press.

**Personnel:** The people connected with high-strength bonding must be conscientious, meticulous and have pride in their work. One smudge of dirt, a thumbprint, or one area where the adhesive has been improperly applied could be covered up in a bond and not show up until a part fails in use. Present methods of quality control of bonded parts depend on statistical analysis of results obtained from destruction testing. Such testing can only be accomplished on a percentage of the units produced. Until a satisfactory method of nondestructive testing has been developed, it will be impossible to completely evaluate each part. Quality is therefore controlled by the personnel who perform the application of the adhesives.

# Tips and Techniques

## Determining Gear Inertia

When computing moment of inertia of a gear in instrument applications, the formula for moment of inertia of a solid disk is usually used:

$$I = \frac{\pi \rho t D^4}{32}$$

where $\rho$ = density of the material, $t$ = face width and $D$ = gear diameter. A plot of moment of inertia versus diameter for a given face width can be a useful aid to obtaining moment of inertia for gears of varying diameters. However, the curve is very steep because the fourth power of the diameter is involved and many points must be plotted to achieve accuracy.

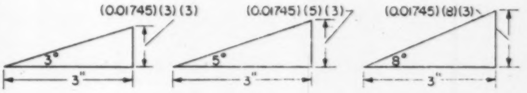
By taking the log of both sides of the equation and plotting log $I$ versus log $D$, the curve becomes a straight line when plotted on log paper. Only two points are then necessary for each value of face width.— Max Fogiel, *New York, N. Y.*

## Drawing Fillets and Radii

Correct radii for drawing fillets and other uses may be quickly determined using a triangle modified for this purpose. Using dividers, scribe a series of concentric circles on the triangle. Each circle should be 1/8-in. larger in diameter than the one preceeding. When all circles are scribed, drill through the center hole using a drill of approximately 1/32-in. diam and countersink the hole. The circle of correct radius can then be quickly matched with other lines on a drawing and the center marked through the hole.—Eugene Gessner, *Towson, Md.*

## Constructing Small Angles

Angles of 10 degrees or less may be constructed with very little error by employing the relationship that 1 degree = 0.01745-radian. To use this relationship, a line of fixed length such as 3 in. is first drawn. A perpendicular is then constructed at one end of this line. Length of the perpendicular should be 3 × 0.01745 × number of degrees, as shown by the sketches. A line joining the ends of the two lines constructed is at the required angle with the first line. Error for angles less than 10 degrees is extremely small.—M. Feinstein, *Westinghouse Electric Corp., Buffalo, N. Y.*



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**DESIGNING ELECTRONIC EQUIPMENT FOR MAINTAINABILITY** *(Twelfth of a Series)*

# *Recommended methods of presenting* Maintenance Instructions

By John D. Folley Jr. and James W. Altman
*Research Scientists*
*American Institute for Research*
*Pittsburgh*

MAINTENANCE instructions that are hard to follow or not adequately presented are difficult to use and may even be avoided. Poor presentations also increase the chance of error in performing specified operations. Ineffective presentations can offset otherwise good design of equipment for maintainability.

Recommended types of data presentations that will serve various maintenance instruction functions are listed in Table 1.

Presentations of maintenance job information or instructions in paragraph form should be avoided. This format tends to obscure the step-by-step nature of procedures, and requires many words where other formats require few.

**Information Content:** Instructions should contain only information relevant to the job. Handbooks of maintenance instructions have frequently contained much information of very limited help to the technician in doing his job.

Instructions must be prepared specifically for each level of maintenance. One set of instructions should spell out the procedures for customer maintenance, another for the field, etc., rather than instructions for all levels being combined into a single set.

Nomenclature of code symbols used on the equipment should be used on job instructions. If a switch on the equipment is labeled PWR SW, the job instructions should refer to this control as PWR SW and not, for example, as "the master power switch." Where control labels on the equipment are particularly cryptic, the complete name of the control can be given in parentheses in the job instructions to clarify the label, for example, PWR SW (Master Power Switch).

Job instructions should present the required signal characteristics and tolerances for each test point. If signal characteristics are not given, the technician will have to figure out what the signal should be or, more likely, measure the signal on a properly functioning piece of equipment. If he cannot do either, the value of the procedure and the test point is lost.

Job instructions should be fully indexed. The index should contain words the technician is likely to look for in locating a particular item in the instructions.

Stock numbers needed for ordering replacement components should be presented with all parts lists.

All information in the instructions should be accurate. This seems almost too obvious to mention. Yet, technicians report that instruction manuals often contain errors. This suggests careful editing by the actual equipment designers or by persons familiar with the design of the equipment. Even a single error in job instructions may cause con-

**Table 1—Recommended Data Presentations for Various Instruction Functions**

| Purpose of Data | Kind of Presentation |
|---|---|
| 1. Describing procedures in detail | 1. Step-by-step instructions |
| 2. Describing procedures for experienced technicians | 2. Check lists |
| 3. Presenting physical features | 3. Drawings and photographs |
| 4. Presenting large amounts of data | 4. Tables and charts |
| 5. Describing processes or interrelationships | 5. Diagrams |

**General recommendations are given here for presenting maintenance information and instructions in the most usable form for the maintenance technician. Suggestions are made on information content, physical characteristics, and revision and availability of instructions. Specific data are included on step-by-step instructions, check lists, drawings and photographs, charts and tables, maintenance diagrams, and signal data-flow diagrams.**

**This is the final article of a twelve-part series dealing with the design of electronic equipment for maintainability. Original material for this series was prepared, under Air Force contract, for the Psychology Branch, Aero Medical Laboratory, Wright Air Development Center, Dayton, O.**

siderable wasted maintenance time and may even result in malfunctioning equipment being passed as operating in tolerance.

**Physical Characteristics:** Job instructions and diagrams that will be used continually will last longer if enclosed in plastic. This suggestion also permits the technician to make notes and erase what he has written after completion of the task, without damage to the materials.

Fold-out pages in manuals should be (1) kept to a minimum, (2) placed at rear of manuals, and (3) be readable with manual opened to another place by leaving blank the part of the sheet that is covered by other pages.

### Table 2—Recommended Presentation of a Step-by-Step Job Instruction

| Step No. | Component | Action | Indication[1] | Remarks |
|---|---|---|---|---|
| 2.1 | Antenna Assy. | Mount azimuth and elevation protractors | | See Drawing P |
| 2.2 | Controls on pilots control box: | Set to: | Antenna travel on protractors is: | |
| | Operation Sw. | Auto-Search | Az: ±23½° | Adjust with |
| | Antenna-Az. Sw. | Center-Narrow | | Pot. P2371 |
| | Antenna-El. Con. | Center | El: ±2½° | Adjust with Pot. P2346 |
| | Pulse Length Sw. | Long | | |
| 2.3 | Antenna-Az Sw.<br>Antenna-El Con. | Center-broad<br>Full clockwise | Antenna travel on protractors is:<br>Az: ±67°<br>El: +30°, −25° | Same as 2.1.1.2 |

[1] This is the particular aspect of equipment performance which the technician should note.

Customer-maintenance manuals should have maximum dimensions of no more than 5½ by 8½ in. and 1½ in. thick so they will fit into a technician's coverall pocket. These manuals should be bound so that they will lie flat, and they should be printed in simple, straight type that has good readability under poor light, even for small type.

Printing of diagrams inside the covers of units is desirable if few modifications are anticipated. When modifications are made, correction sheets must be supplied to be pasted over the printed diagrams.

Attaching job instructions to auxiliary equipment is sometimes desirable. For example, a test set used only for aligning a particular computer could have a roll chart on the front panel that gives specific instructions for making the alignment. When roll charts are used for presenting procedures at least three steps of the procedure should be visible through the viewing window. This is particularly important when warnings may be included in various steps. The middle step should be emphasized by lines painted on the viewing window.

**Revision and Availability:** Job instructions should be kept current with modifications of the equipment. This is especially important when power voltages and/or signal characteristics change from one model to the next.

Whenever new models of an equipment are introduced, old job instructions should not be rescinded until all old models are withdrawn from use. However, job instructions definitely should be available for the new equipment.

### Table 3—Check List Type of Instruction

| Step No. | Action | Indication | Technician's Remarks |
|---|---|---|---|
| 2.1 | Mount protractors on antenna assembly | | ✓ |
| 2.2 | Set controls for narrow scan center | Az: ±23½°<br>El: ±2½° | No vertical scan<br>O.K. |
| 2.3 | Set controls for broad scan center | Az: ±67°<br>El: +30°<br>−25° | No vertical scan<br>O.K. |

**Step-by-Step Job Instructions:** This type of job instructions is well suited to maintenance tasks since it is set up for a sequence of steps. Each procedure can be divided into a series of steps and each step broken into a number of elements.

A format shown in Table 2 is strongly recommended for the presentation of procedural job instruction.

**Check Lists:** This less detailed form of instructions is especially useful to more experienced technicians. The division of procedural steps into elements is eliminated and the goal of each step presented as a reminder to the technician.

Customer technicians are quite likely to find checklists helpful because they often must work in places where detailed instructions are inconvenient to use. The designer should provide a standardized check list of instructions for customers, Table 3.

**Drawings and Photographs:** These two pictorial presentations of information can be very valuable for supplementing written job instructions. Generally speaking, good quality drawings will probably be at least as effective as photographs for this purpose. Photographs frequently show too much detail, thereby obscuring the particular item they are illustrating. On the other hand, photographs with irrelevant details blanked out and relevant details clearly shown can be very effective.

Drawings illustrating job instructions should include only the detail needed for the illustration. Extraneous detail in such drawings tends to obscure the point.

The purpose of including drawings in job instructions should be either to clarify written instructions or to provide information the technician needs for maintenance operations. Drawings inserted only for humor or aesthetic reasons probably add little to the value of the instructions.

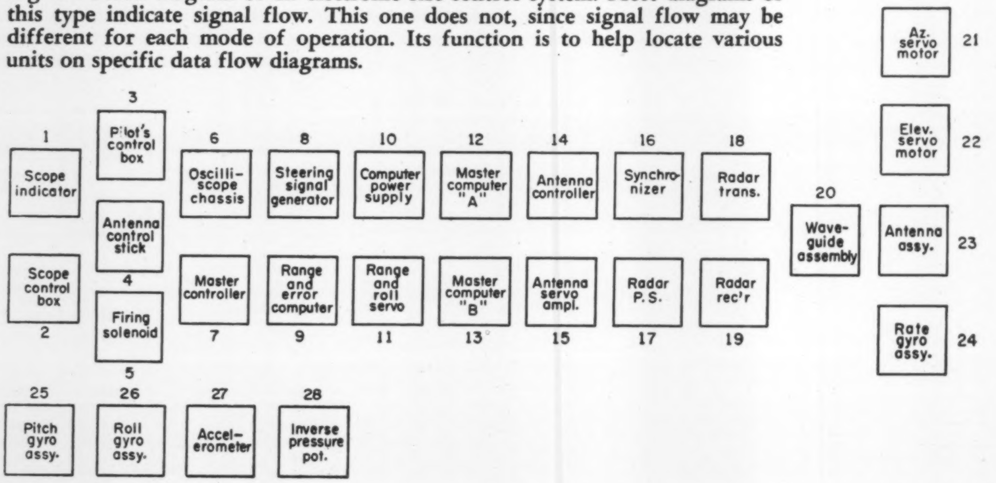
**Tables and Charts:** Tables are probably the most efficient way to present large amounts of data. Whenever similar information is to be presented concerning a number of different equipment components, tables may be particularly useful. For tables to be of maximum value, however, the maintenance job instructions should specify when and how each table should be used.

Information included in tables should be directly usable by the technician without his having to make any data transformations. Engineering test data, for example, are of little value to the technician. This same basic information translated into indications he should observe in the equipment may be indispensable to effective maintenance.

**Maintenance Diagrams:** The use of the term "diagram" is limited here to what may be loosely described as a map of either the physical features or functional interconnections of the equipment. Three types of diagrams are in common use:

*Functional block diagrams* usually suggest the general direction of signal flow from one major

Fig. 1—Block diagram of an electronic fire-control system. Most diagrams of this type indicate signal flow. This one does not, since signal flow may be different for each mode of operation. Its function is to help locate various units on specific data flow diagrams.


1 Scope indicator
2 Scope control box
3 Pilot's control box
4 Antenna control stick
5 Firing solenoid
6 Oscilli-scope chassis
7 Master controller
8 Steering signal generator
9 Range and error computer
10 Computer power supply
11 Range and roll servo
12 Master computer "A"
13 Master computer "B"
14 Antenna controller
15 Antenna servo ampl.
16 Synchro-nizer
17 Radar P.S.
18 Radar trans.
19 Radar rec'r
20 Wave-guide assembly
21 Az. servo motor
22 Elev. servo motor
23 Antenna assy.
24 Rate gyro assy.
25 Pitch gyro assy.
26 Roll gyro assy.
27 Accel-erometer
28 Inverse pressure pot.

component of the system to another, Fig. 1. This type of diagram does not usually reflect the physical appearance or layout of the equipment.

*Layout or wiring diagrams* show the physical connection of equipment components with each other. Layout diagrams in particular reflect the actual physical structure of the equipment. Layout or wiring diagrams usually do not indicate either the direction or characteristics of signal flow.

*Schematic diagrams* show the electrical characteristics of components and the way in which the components are combined into circuits. They usually do not reflect the physical layout of the equipment or present the nature of signal flow among components.

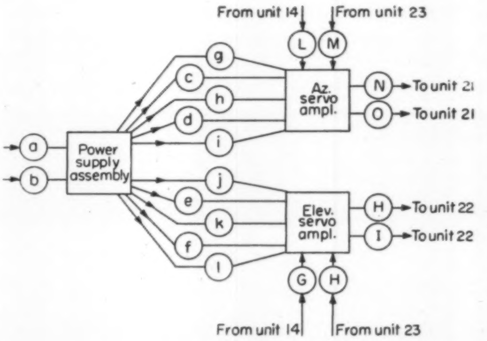

From unit 14
From unit 23
L
M
g
c
h
d
i
a
b
Power supply assembly
Az. servo ampl.
N
O
To unit 21
To unit 21
j
e
k
f
l
Elev. servo ampl.
H
I
To unit 22
To unit 22
G
H
From unit 14
From unit 23

Fig. 2—Data-flow diagram for field-level technicians of unit 15 in the block diagram shown in Fig. 1. Chief function of diagram is to show signal flow between components. Tables of in-tolerance check readings, set-up of equipment, and recommended sequence of checks could be presented with this dia-

Each of these types of diagrams can serve a useful function in the developmental sequence of a system. None, however, is specially prepared for use in maintenance operations, with the exception of a few equipment manufacturers' "loop books" or "servo diagrams."

The type of diagram which is quite useful to technicians is the data-flow diagram. This type of diagram includes features of each of the standard diagrams just discussed plus certain additional features.

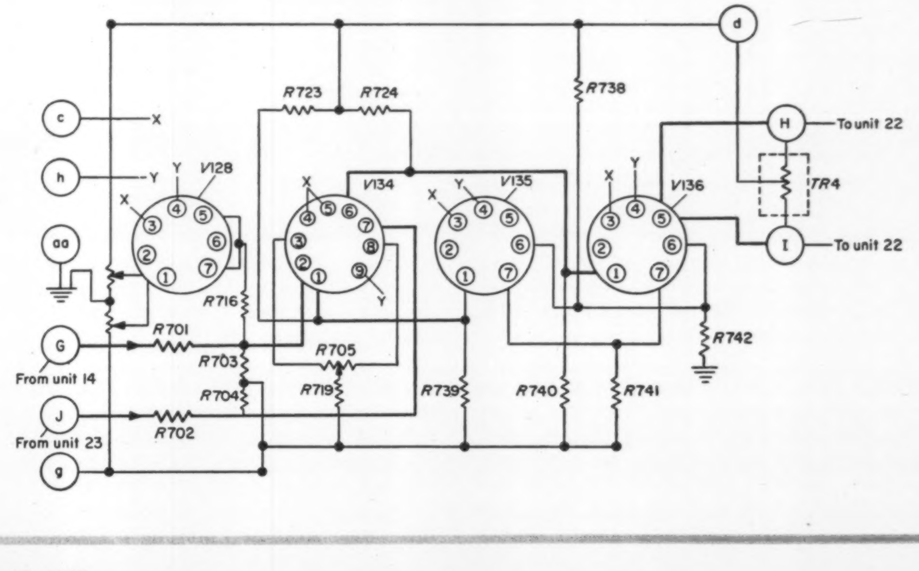
Maintenance diagrams should reflect equipment unitization. For example, the "building block" of the customer maintenance diagram should be the customer-replaceable unit. The value of unitized equipment will be severely reduced if this recommendation is not followed.

All of a particular circuit or loop should be on a single page insofar as possible. One exception occurs where trouble shooting is within a particular unit and the circuit runs from that unit to another unit and then returns. Then, it may be desirable to present on a single page only that portion of the circuit which is within the suspected unit.

Usually diagrams for customer technicians should be about 5½ by 8½ inches, since this size will fit easily into work-uniform pocket.

Facilities for using large diagrams, for example, 18 by 24 in., are usually adequate in the field or

Fig. 3—Data-flow diagram for field or factory-level technicians for elevator servo-amplifier portion of the data-flow diagram illustrated in Fig. 2.


d
c
X
h
Y
aa
G
From unit 14
J
From unit 23
g
V128
V134
V135
V136
X
Y
R723
R724
R738
H
To unit 22
TR4
I
To unit 22
R716
R701
R703
R704
R702
R705
R719
R739
R740
R741
R742

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in factories. Special stands or other provisions might make use of large-size diagrams more convenient.

Fold-over, map-board, and roll-chart types of stands are all convenient for large diagrams in the field and in factories. Diagrams on fold-over stands should probably be plastic coated to protect the diagram and to permit the technician to make notes that can be easily wiped off. A glass plate on the front of a roll chart will serve the same purpose. Diagrams on map-board type stands should be printed on a durable cloth-like material.

Diagrams similar to those just described should be used for all subsystems and units of equipment. It should be possible to trace signals from diagrams for one unit or subsystem to diagrams for another unit or subsystem. Where signals are shown leaving a page, the component of the equipment to which it goes should be indicated. The page on which the signal can be picked up again for tracing should also be given.

A table of contents and index of diagrams should be given. Color may be used to advantage on diagrams to code test points, types of signal flow, and classes of components.

**Data-Flow Diagrams:** These are prepared specially for use in maintenance and contain only information needed to perform specified maintenance activities. Components are shown in the same relative position as in the equipment so far as this is practical.

Components are not pictured or schematized; only enough information is presented to identify them, Fig. 2. Chief emphasis is given to the nature of the signal flow between components, particularly at points where "power on" checks can be made. Data-flow diagrams deal only with the electrical characteristics of the signal, not with the electrical characteristics of components.

Flow of fixed-voltage supplies to components may be indicated in special color or even omitted from the diagram completely. If the latter is the case, information concerning these voltage supplies may be presented on a separate diagram or in table form.

The appearance of data-flow diagrams is similar whether they deal with data flow among major units, assemblies, or subassemblies. A diagram of signal flow among parts may look like a combination of a schematic and a wiring diagram, Fig. 3.

Data-flow diagrams are based on a particular configuration of control settings for the prime equipment and/or test equipment. They may also be based on certain manually induced special conditions, such as broken feedback loops or servos set to a particular position. The control settings and special conditions are indicated on the diagram.

The electrical characteristics of the signal to be checked at each test point is shown on the data-flow diagram. When it is necessary to check complex time and shape characteristics of the signal, the required information can be keyed to tables at the edge of the diagram or to separate pages.

No information is given about the nature of signal flow within units that are replaceable or throw-away at the level of maintenance for which the diagram was prepared.

### BIBLIOGRAPHY

This article is the twelfth and last in a co-ordinated series by John D. Folley Jr. and James W. Altman. Previous articles, and issues of MACHINE DESIGN in which they appeared are:

| | |
|---|---|
| Designing Electronic Equipment for Maintainability | June 14, 1956 |
| Units, Assemblies and Subassemblies | June 28, 1956 |
| Covers and Cases | July 12, 1956 |
| Wiring, Cables and Connectors | July 26, 1956 |
| Maintenance Accesses | Aug. 9, 1956 |
| Test Points | Sept. 6, 1956 |
| Controls | Sept. 20, 1956 |
| Displays | Oct. 4, 1956 |
| Equipment Installation | Oct. 18, 1956 |
| Maintenance Auxiliaries | Nov. 15, 1956 |
| Maintenance Procedures | Dec. 13, 1956 |

## *Static Electrical Controls*

In the article by John C. Ponstingl on "Static Electrical Controls," November 29, 1956, three of the typical curves in Table 3 on Page 97 were incorrectly located. The third curve from the bottom should appear with the phototransistor, the fourth curve from the bottom with the transistor, and the fifth curve from the bottom with the cadmium-sulfide and lead-sulfide photocells.

In Figs. 13*a* and *b*, the letter designations on the terminals of actuator coils should be the same as the coil designations.

" . . . the American design engineer, in contrast with his European competitor, tends to restrain those design features that adversely affect cost if the quality gained thereby is small. This is not due to variations between engineering teaching in America as compared to Europe (the subject matter is amazingly identical) but is fundamental to the American designer because of his American habit of measuring everything in terms of money. The result of this sort of design is a tremendous over-all savings in labor and in costs."—WILLIAM A. HADLEY, *director, Research and Engineering Div., Mergenthaler Linotype Co., Brooklyn, N. Y.*

MACHINE DESIGN
**Data Sheet**

# *Angular Relationships of a* **Geneva Mechanism**

## *During Indexing Movement*

By Sol Dudnick,
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*Maryland Cup Company*
*Baltimore, Md.*

THE Geneva mechanism is widely used for accurate intermittent or partial rotation of a driven shaft. Frequently in the application of such drives it is necessary to have work performed during the indexing portion of the cycle. In such cases it is usually necessary to know the exact instantaneous position of the driven gear for any position assumed by the driving gear. Presented here are the various formulas for determining this relationship. Also included are plots for various numbers of stations showing characteristic displacement curves.

**Example 1:** Assume that the position of the driven gear in a 6-station Geneva is desired when the position of the driving gear $\alpha = 42$ degrees.

From Table 2 for $n = 6$, $a/r_1 = 2$. For $\alpha = 42$ deg, $\sin \alpha = 0.6691$ and $\cos \alpha = 0.7431$. Then with

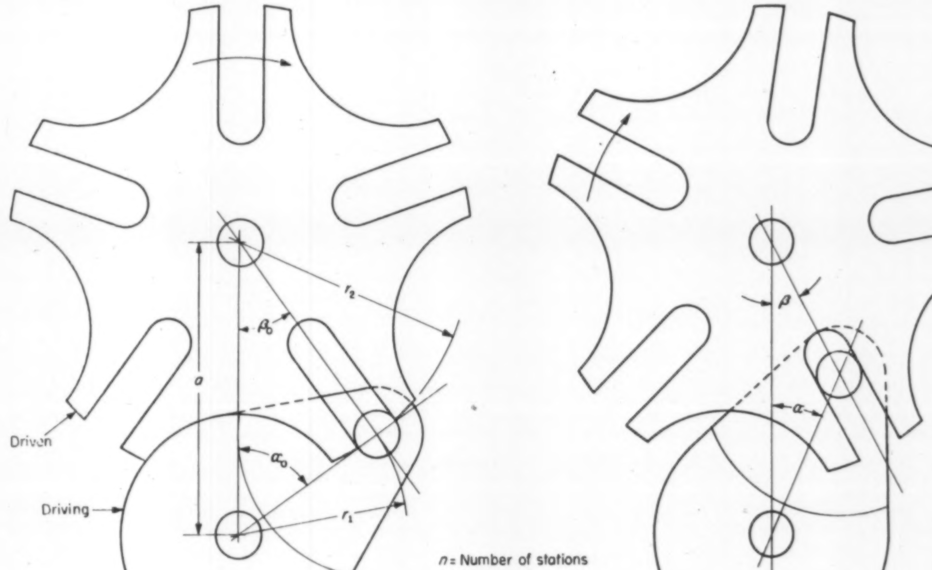

Fig. 1—Geneva mechanism in the position at commencement of motion, *a*, and a general position during indexing motion, *b*.

## Table 1—Equations

| | Driving | Driven |
|---|---|---|
| **Half-Angle** | $\alpha_0 = 90 - \beta_0$ | $\beta_0 = \dfrac{180}{n}$ |
| **Angular Position** | $r_1 = a \sin \beta_0$ | $r_2 = a \cos \beta_0$ |
| **Radius** | $\alpha = 180 - (\beta + \gamma)$<br>$\sin \gamma = \dfrac{a}{r_1} \sin \beta$ | $\tan \beta = \dfrac{\sin \alpha}{\dfrac{a}{r_1} - \cos \alpha}$ |

the equation for angular position of driven gear from Table 1,

$$\tan \beta = \frac{0.6691}{2 - 0.7431} = 0.5323$$

$$\beta = 28° \, 1' \, 40''$$

**Example 2:** If a number of closely spaced locations are desired, a graph may be plotted from several computed values and intermediate points found by interpolation. Assume from Example 1 that the location of the driven gear is desired when the driving gear is within the range of 41 to 43 degrees from the center line. From the method used in Example 1, the values of $\beta$ are determined as:

$$\text{when} \quad \begin{aligned} \alpha &= 41, \beta = 27° \, 47' \; \, 0'' \\ \alpha &= 42, \beta = 28° \; \, 1' \, 40'' \\ \alpha &= 43, \beta = 28° \, 15' \, 45'' \end{aligned}$$

These values are plotted in Fig. 3. Intermediate values may be determined quite accurately without further computations. For example, when $\alpha$ is 41 deg 45 min, $\beta$ is read directly as 27 deg 57.7 min. More information on Geneva mechanisms may be found in an article by Otto Lichtwitz—"Mechanisms for Intermittent Motion," Part 1, MACHINE DESIGN, December, 1951, Pages 134-148.

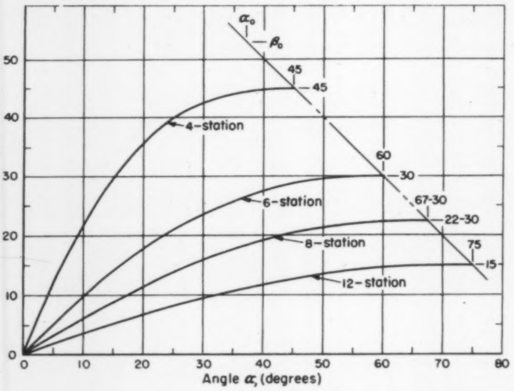

Fig. 2—Angular locations of driving and driven gears from centerline through half-angle of contact range.

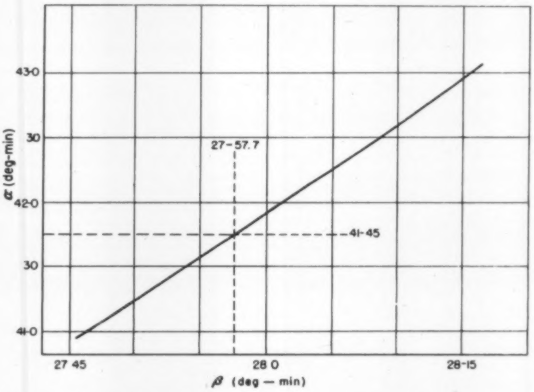

Fig. 3—Partial curve for determining values of $\beta$ in a 6-station Geneva when $\alpha$ ranges from 41 to 43 degrees.

## Table 2—Values of Geneva Relationships

| Number of Stations $n$ | Half-Angle (deg-min) $\alpha_0$ | Half-Angle (deg-min) $\beta_0$ | Angular Ratio $\alpha_0/\beta_0$ | Ratio of Center Distance to Radius $a/r_1$ | Ratio of Center Distance to Radius $a/r_2$ | Duration of Motion Driving : Driven $(\alpha_0/\beta_0)/n$ |
|---|---|---|---|---|---|---|
| 3 | 30 | 60 | 0.5 | 1.1547 | 2 | 1:0.1667 |
| 4 | 45 | 45 | 1 | 1.4142 | 1.4142 | 1:0.25 |
| 5 | 54 | 36 | 1.5 | 1.7013 | 1.2361 | 1:0.3 |
| 6 | 60 | 30 | 2 | 2 | 1.1547 | 1:0.3333 |
| 7 | 64–17.14 | 25–42.86 | 2.5 | 2.3047 | 1.1099 | 1:0.3571 |
| 8 | 67–30 | 22–30 | 3 | 2.6131 | 1.0824 | 1:0.375 |
| 9 | 70 | 20 | 3.5 | 2.9238 | 1.0642 | 1:0.3889 |
| 10 | 72 | 18 | 4 | 3.2362 | 1.0514 | 1:0.4 |
| 12 | 75 | 15 | 5 | 3.8637 | 1.0353 | 1:0.4167 |

## DESIGN ABSTRACTS

*Selecting methods for*

# Filing Engineering Drawings

By Lester Gerber

*Project Director*
*National Records Management Council Inc.*
*New York*

IN THIS discussion, the term "engineering drawings" is used to include tracings, blueprints, and similar material. Four major types of equipment are available for filing these drawings: horizontal or flat files, hanging files, vertical files, and roll files. These four major types are manufactured in different sizes to correspond with the varying sizes of engineering drawings.

The following descriptions are a representative selection of each type of equipment:

1. HORIZONTAL OR FLAT FILES. Ten-drawer unit; approximate size—43 in. wide, 28 in. deep, and 41 in. high; drawers 2½ in. high.

2. HANGING FILES. Closed metal cabinet, fitted with hangers; approximate size—36 in. wide, 39 in. deep, and 72 in. high. (This type of file is also made as an open unit with a metal or wood frame.)

3. VERTICAL FILES. Vertical file with access from the top, fitted with pockets and compressor springs; approximate size—43 in. wide, 30 in. deep, and 36 in. high. Three, four, and five-drawer vertical filing cabinets are also available.

4. ROLL FILES. Closed metal cabinet with filing bins designed to hold 112 open fiber tubes vertically. The tube unit is permanently fixed and tilts forward. Variations of roll files are pigeon holes and open shelving units designed to hold drawings horizontally with and without tubes.

**Evaluation Factors:** There are six basic factors essential to judging the desirability of equipment:

1. Cost
2. Accessibility
3. Protection against wear and tear
4. Protection from environment
5. Security
6. Space utilization

Cost considerations involve two factors:

1. Average purchase price for standard units of equipment.
2. Cost per year of filing one drawing, reflecting both purchase price and space utilization. This is a summary figure calculated from initial purchase price, capacity and square footage occupied by the unit. The annual cost figure is the cost of equipment to house one drawing plus the cost of the floor space occupied by the equipment, Table 1.

Accessibility means ease of filing, finding, removing and returning a drawing to the unit.

Protection against wear and tear is the protection provided by the equipment against a drawing being torn, wrinkled, cracked, smudged, etc., either accidentally or in the course of normal filing and finding.

Protection from environment is the protection provided by the equipment against a drawing being damaged by dust, dirt, grime, moisture, etc.

Security involves the protection provided by the equipment itself against unauthorized or chance scrutiny of a drawing in the course of normal operation without the aid of additional safeguards.

Space utilization is reflected by the following three measures:

1. Capacity: The number of active drawings that may be filed in one standard unit.
2. Drawing capacity per square foot of space: Equipment capacity to floor area occupied is determined by dividing the capacity of a standard unit by the number of square feet of floor space. The higher the resulting figure, the better.
3. Drawing capacity per cubic

### Table 1—Cost Ratings for Filing Equipment

| Annual Cost per Drawing (dollars) | Cost Rating |
|---|---|
| 0.12 or more | Very high |
| 0.10-0.12 | High |
| 0.075-0.10 | Moderately high |
| 0.035-0.075 | Moderate |
| 0.025-0.035 | Low |
| 0.025 or less | Very low |

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## Table 2—Summary Comparison of Filing Equipment

| Equipment | Purchase Price | Cost (dollars) Per Year For Filing One Drawing Active | Cost (dollars) Per Year For Filing One Drawing Inactive | Accessibility | Protection against Wear and Tear | Protection from Environment | Security | Space Utilization (number of drawings) Per Unit Active | Per Unit Inactive | Per Square Foot Active | Per Square Foot Inactive | Per Cubic Foot Active | Per Cubic Foot Inactive |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Horizontal or Flat Files** | | | | | | | | | | | | | |
| Drawers 2½" high | 300 | 0.061 | 0.046 | Fair to Good | Fair to Good | Excellent | Excellent | 1500 | 2000 | 80 | 100 | 23 | 30 |
| Drawers 1" high | 185 | 0.127 | 0.095 | Good | Fair to Good | Excellent | Excellent | 660 | 880 | 35 | 47 | 20 | 27 |
| **Hanging Files** | | | | | | | | | | | | | |
| Closed metal cabinet with hangers | 150 | 0.021 | 0.016 | Good | Fair to Good | Good | Good | 4000 | 5000 | 210 | 265 | 35 | 44 |
| Open metal frame with hangers | 100 | 0.078 | 0.067 | Excellent | Fair | Poor | Poor | 1300 | 1500 | 54 | 63 | 11 | 13 |
| Open wooden racks | 50 | 0.152 | 0.115 | Good | Fair | Poor | Poor | 750 | 1000 | 27 | 36 | 8 | 10 |
| **Vertical Files** | | | | | | | | | | | | | |
| Access from top, pockets and compressors | 410 | 0.028 | 0.021 | Good | Good | Excellent | Good | 3000 | 4000 | 185 | 250 | 62 | 84 |
| Filing cabinet, 3-drawer, pockets and compressors | 340 | 0.035 | 0.026 | Very Good | Very Good | Very Good | Excellent | 1500 | 2000 | 165 | 225 | 39 | 52 |
| Filing cabinet 5-drawer follower-block | 110 | 0.030 | 0.024 | Very Good | Good | Good | Very Good | 1000 | 1250 | 165 | 210 | 35 | 43 |
| **Roll Files** | | | | | | | | | | | | | |
| Closed metal cabinet, bin, tubes | 190 | 0.129 | 0.103 | Fair | Fair to Good | Very Good | Very Good | 400 | 500 | 38 | 47 | 6 | 7 |
| Pigeon holes | 150 | 0.123 | 0.074 | Fair to Good | Fair to Good | Fair to Good | Fair to Good | 600 | 1000 | 37 | 60 | 6 | 10 |
| Open shelving, closed tubes | 150 | 0.037 | 0.025 | Fair | Fair to Good | Excellent | Good | 2000 | 3000 | 120 | 180 | 17 | 26 |
| Open shelving | 50 | 0.069 | 0.046 | Fair | Fair | Poor | Poor | 1000 | 1500 | 60 | 90 | 10 | 15 |

foot: Since this figure includes height, it is valuable in judging those units of equipment that can be stacked one on the other within the same space. The drawing capacity is determined by dividing the capacity of a standard unit by the number of cubic feet utilized by the unit.

**Ranking of Factors:** The six factors just described are not of equal importance. To decide the order in which to rank these factors, the National Records Management Council weighed the comments of engineers, draftsmen, file supervisors and equipment manufacturers, and then measured them against the Council's experience in the actual installation of records control.

For active filing in the office, the consensus ranks the evaluation factors in the following order:

1. Accessibility
2. Space utilization
3. Protection against wear and tear
4. Cost
5. Protection from environment
6. Security

For inactive or semiactive filing in records storage, the factors were rated as follows:

1. Space utilization
2. Cost
3. Accessibility
4. Protection from environment
5. Protection against wear and tear
6. Security

These rankings are by no means to be considered hard and fast. Each person responsible for the filing of engineering drawings must determine for his own organization the importance of the six factors and evaluate equipment accordingly.

**Analysis of Equipment:** The available equipment may be analyzed by applying the six evaluation factors. Table 2 summarizes the findings and ratings of various types of equipment.

In using the table, it is essential that the ratings for one factor be balanced against those for the other factors. For example, the only type of equipment rated "excellent" on accessibility is rated "poor" as to security. If the drawings are not classified information, the poor security is insignificant. By the same token, the high accessibility rating makes this same equipment most desirable for material frequently referred to. However, if security is a prime consideration, either another type of equipment should be selected or the entire filing area should be protected by using bars, vault doors or other safeguards.

In judging the cost factor, the initial purchase price should be considered in conjunction with the annual cost of filing a drawing. Some equipment is comparatively inexpensive to purchase or construct, but the annual cost of filing a drawing may run quite high. The cost element also must be balanced against the other factors. For example, the equipment that rates "excellent" on accessibility rates "moderate to moderately high" on summary cost. It must be reiterated that the final decision should rest with the individual organization after it applies to its own operations the six basic criteria.

**Rating Equipment:** In order to plot the six rating factors visually, the Council has developed a rating scale. The rating scale permits a quick comparison of the six rating factors in relation to the individual needs. The procedure is as follows:

STEP 1: Rank the six rating factors—accessibility, cost per drawing per year, protection from environment, protection against wear and tear, and security, in order of their importance. In the examples illustrated later, accessibility was ranked first, protection against wear and tear ranked second, while security ranked last.

STEP 2: Prepare a chart. In the left-hand column list the factors in their order of importance. In column two, opposite each factor post numerical factors in order of rank; Table 3.

### Table 3

| Factor ranked | Is weighted by |
|---|---|
| First | 6 |
| Second | 4 |
| Third | 3 |
| Fourth | 2 |
| Fifth | 1 |

Thus, accessibility in our example has a weight of six points, while security is rated at one point.

STEP 3: At the top of the chart list the three additional column headings: Rating, Points, and Score.

STEP 4: Mark down in the rating column the evaluation of each factor for the specific equipment being rated. For example, for the vertical file with accessibility from the top, "accessibility" is rated as "good." Write "good" opposite accessibility. Continue the procedure until each factor is given its adjective rating.

STEP 5: Mark down in the point column the point values assigned to each factor in accordance with the rating shown in Table 4. For example, the "good" rating for accessibility to the vertical file is worth 4 points, the "excellent" rating for protection against wear and tear is worth 6 points, and so on. The one variation from this procedure is in rating the "cost" factor. This factor is rated by cost per drawing per year, Table 5.

### Table 4

| When factor is rated | Score points as |
|---|---|
| Poor | 0 |
| Fair | 2 |
| Good | 4 |
| Very good | 5 |
| Excellent | 6 |

### Table 5

| When cost per drawing is (cents) | Equipment cost is rated | Score points as |
|---|---|---|
| Over 12 | Very high | 0 |
| 10-11.9 | High | 2 |
| 7.5-9.9 | Moderately high | 4 |
| 3.5-7.4 | Moderate | 6 |
| 2.5-3.4 | Low | 8 |
| Under 2.5 | Very low | 10 |

STEP 6: Multiply the weight factor in column two by the points given to each rating. This gives the combination of how important each factor is (by order of rank) and how well the equipment rates on each factor.

STEP 7: Total the number of points. The higher the point score, the better the equipment will meet individual needs. The completed chart is shown in Table 6.

### Table 6

| Factor | Weight | Rating | Points | Score |
|---|---|---|---|---|
| Accessibility | 6 | Good | 4 | 24 |
| Protection against wear and tear | 4 | Good | 4 | 16 |
| Costs (per drawing per year) | 3 | Low | 8 | 24 |
| Protection from environment | 2 | Excellent | 6 | 12 |
| Security | 1 | Good | 4 | 4 |
| | | Total | ........ | 80 |

**Conclusions:** The many types of equipment currently available satisfy most needs and preferences. On the basis of the study completed by the National Records Management Council, the following conclusions may be drawn:

1. Each individual must, in the final analysis, rate the equipment for his own particular set of conditions and preferences. The rating scale can only be used as a guide to those faced with the problem of selecting storage equipment for engineering drawings.

2. For active filing in an office area, hanging or vertical units are preferable. Both rate well with respect to accessibility and are marked by low annual cost for filing drawings. Filing cabinets with access from the front are well suited to smaller drawings. The drawings are accessible and protected. The cost per drawing per year is low when small drawings are filed.

3. For inactive filing, those units that can be stacked provide good value. The use of open shelving and closed tubes offers good protection and security at a low annual cost per drawing. The disadvantages of a possible accident hazard with stacked units, and of indexing with shelving units can be more than offset by the savings in cost. Reasonable precautionary measures and improvisations to meet individual conditions can be instituted at reasonable costs and little work.

4. Very long drawings (over 48 in. long) are best filed in files which provide an effective combination of maximum protection, accessibility and reasonable cost.

*From a paper entitled "Standards for Filing Engineering Drawings" presented at the ASME Annual Meeting in New York, November,* 1956.

# *Flame-Sprayed Ceramic Coatings*

## for high-temperature applications

By A. P. Shepard

*Chief Development Engineer*
*Metallizing Engineering Co. Inc.*
*Westbury, L. I., N. Y.*

ALUMINA and zirconia are ceramics well adapted to flame spraying. They have low thermal expansion coefficients as compared to most metals and alloys. This characteristic is essential where coatings must function as thermal barriers, as on parts which receive some cooling influence on the side opposite the coating.

There are two reasons why the coefficient of expansion of the coating material must be low. First, a sharp thermal gradient exists within the coating itself, and a high expansion coefficient would set up stresses which would cause the coating to disintegrate. Second, the mean temperature of the coating will be much higher than that of the metal to which it is applied, so the coating must have a low expansion coefficient to reduce stresses between coating and metal.

Ideally, where a thermal gradient exists, a gradient in the expansion coefficient should exist. Composite ceramic coatings, formed by applying zirconia over alumina, or alumina over zirconia, are a step in this direction.

**Advantages:** Several advantages are apparent for thermal barriers of this type, applied to jet engine combustion chambers or rocket nozzles for example. First, the high hardness and high melting temperature of the ceramic provides resistance to surface deterioration. Second, the operating temperature of the metal shell is reduced, permitting equivalent strength with thinner sections. Third, the need for superalloys may be eliminated in some cases, because of lowered operating temperatures. Protection against oxidation may be provided with thin sprayed coatings of heat-resistant alloys beneath the ceramic coating or on the opposite side of the member if required. A fourth possible advantage may reside in increased thermal efficiency of the engine or rocket, since an incandescent ceramic skin would not be expected to cool the outer boundaries of the gas stream as would a much cooler metal surface.

Where the coating is not subjected to high temperatures, the resistance of flame-sprayed ceramics to impact and to abrasion may be greatly improved by impregnating. Phenolics, furanes, silicones, epoxy-based formulations, and a variety of other organic and inorganic impregnants have been used successfully. In general, those materials which show good physical properties should be used. For example, phenolics and furanes are excellent impregnants. The heat-cured types are preferred, because of superior physical properties, but good results have been obtained with catalyzed or air-dried types.

Some of the properties of alumina-base and zirconia-base coatings are shown in Table 1.

**Applications:** A number of practical applications for alumina-base coatings are:

1. Coating fan blades subject to abrasion. Fine particles of abrasive have no effect on alumina coatings. Heavy abrasion, as by sand blasting, will break down the coating by impact, but the effect of fine abrasives is negligible. Alumina coatings sealed with a baked or catalyzed phenolic are relatively impermeable and will withstand a great deal of mechanical abuse.

### Table 1—Properties of Typical Alumina-Base and Zirconia-Base Coatings

| Property | Alumina | Zirconia |
|---|---|---|
| Melting point (F) | 3700 | 4600 |
| Bulk density (g/cc) | 3.2 to 3.4 | 5.2 to 5.3 |
| Porosity (per cent) | 6 to 10 | 6 to 10 |
| Thermal expansion (per deg F $\times 10^{-6}$) | 4.3 | 6.4 |
| Hardness (Moh's scale) | 9.0 | 8.0 |
| Thermal conductivity* (Btu/hr/sq ft/in./deg F) | 19 | 8 |
| Deposition (sq ft/hr, 0.010-in. thick) | 15 | 10 |
| Color | Gray | Tan-Brown |

*On this same scale 18-8 stainless steel would read 185 and carbon steel 320.

2. Special corrosion problems that may be solved by impregnating alumina coatings with an appropriate sealer. The alumina provides physical integrity and is completely inert to most chemicals. The sealer may be selected on the basis of resistance to the specific reagent involved, without the need of considering the physical properties of the sealer.

3. Gages, surface plates, instrument ways. Alumina coatings may be ground with diamond wheels, or even with silicon-carbide wheels, to produce a fairly smooth and very hard corrosion-resistant surface having a low friction coefficient. Impregnation with microcrystalline wax or other sealants may be used where corrosive conditions are severe. Solid lubricants such as molybdenum disulphide or graphite may be added to the impregnant for special bearing applications. Nearly all metals will run against such surfaces with very low friction and no tendency to gall.

4. Use on special-purpose bearings, processing rolls, filters, mixer or agitator parts, and a host of other possible applications which can be expected to develop with time. Even though somewhat porous (6 to 10 per cent), alumina coatings have a compressive strength in excess of 200,000 psi. Pores may be filled with an appropriate sealer, with a lubricant, or left unfilled as required.

5. Both alumina and zirconia coatings are completely resistant to nearly all molten metals, although some of the common fluxes (for example zinc-ammonium chloride) will penetrate the coating and attack the base.

*From "Notes on Sprayed Ceramic Applications" in* Metco News, *Vol. 8, No. 3, published by Metallizing Engineering Co. Inc.*

take
a
look
at
the

# Big News in Stereo Viewers

*Chicago Molded uses phenolic of top dimensional stability*

The new, prestige-building Realist Stereo Viewer at the left is now being offered by the David White Company of Milwaukee, Wisconsin.

It features: optional power for illumination – *either from a light socket or battery;* knob-easy brightness control; a new focusing adjuster; a thumb wheel interocular adjuster that permits each viewer to set the proper distance between eyes.

**The viewer** is making big news in plastics, too! The eleven parts you see above are all custom molded. For top dimensional stability so vital in precision optical equipment, Chicago Molded has used an improved, compression molded phenolic that is highly impact resistant. For sales appeal and quick product identification six parts are a sprightly green polystyrene. For production economy, all six have been injection molded at one time in a six-cavity mold.

**Whatever your** new product needs, you'll find *it pays* to call in Chicago Molded. CMPC engineers keep abreast of developments in plastics to help you make your product more saleable, yet less costly. *That's why 60% of our business comes from firms we've served for over 15 years.*

Write today for a free subscription to *Plastics Progress,* Chicago Molded's data packed magazine on up-to-date developments in plastics.

**CHICAGO MOLDED PRODUCTS CORP.**
**1028 North Kolmar Avenue, Chicago 51, Illinois**

Circle 441 on page 19

# HELPFUL LITERATURE

## for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

### Aircraft Tube Fittings

"Aircraft Piping and Engineering Application Manual" deals with data on cluster fittings, installation and assembly methods, piping application categories, and engineering recommendations. Also presented is information on design, selection and installation of various aircraft piping systems. 44 pages. Weatherhead Co., Aviation Div.

*Circle 501 on page 19*

### Hydraulic Systems

Hydraulic systems for turbo-jet and turboprop aircraft engines are discussed in bulletin A5211 entitled "Vickers Looks Ahead to the New Engines." High temperature tests of hydraulic components are described. Covered are hydraulic pumps, motors, controls, servos and starters. 8 pages. Vickers Inc.

*Circle 502 on page 19*

### Metal Laminates

Company's new laminates are combinations of two or three metals permanently and metallurgically bonded together to form one "sandwich." Properties, applications, types, sizes and other engineering details are provided on these laminates in bulletin 10NE6. 8 pages. Bridgeport Brass Co.

*Circle 503 on page 19*

### Die Cast Gears & Pinions

Spur and cup gears as well as pinions produced from stock dies are listed in data sheet. Combinations of gears, pinions, hubs and shafts can be made to specification at low cost. 2 pages. Gries Reproducer Corp.

*Circle 504 on page 19*

### Hydraulic Tube Fittings

Design, dimension and ordering information on complete line of straight-thread fittings for hydraulic tubing is contained in catalog ST-56. Metal ring, captive nut and O-ring sealing types are included in styles for every purpose. 24 pages. L & L Mfg. Co.

*Circle 505 on page 19*

### Photoelectronic Edge Control

Linar Edgetrol photoelectronic edge guidance system for the precise control of edge register of moving material is subject of two illustrated bulletins. Operation is by means of electric light beams, without force or pressure applied to material. 4 pages each. Intercontinental Dynamics Corp.

*Circle 506 on page 19*

### Static Magnetic Controls

"Cypak Magnetic Control" is title of manual TD 52-760 which deals with magnetic controls and logic functions for industrial control. Discussed are basic "and," "or," "not," and "memory" logic functions; the circuitry providing these functions, including the basic Ramey magnetic amplifier circuit; and current applications to industrial control. 8 pages. Westinghouse Electric Corp.

*Circle 507 on page 19*

### Heat Exchangers

Shell and tube heat exchangers for hydraulic equipment, diesel and gas engines, transformers, machine tools, coolants and processes in chemical, food and pharmaceutical fields are subject of illustrated catalog 1156. Selection and heat exchange data and formulas are included. 16 pages. Young Radiator Co.

*Circle 508 on page 19*

### Filter-Regulator-Lubricator

Adaptable for air and some gas services, line of pressure regulators, lubricators and filters is offered for ¼ to ½-in. fluid lines. Also available are combinations of two or three of these units for pressures to 250 psi and 300°F. Full specifications are given in bulletin F-15A. Watts Regulator Co.

*Circle 509 on page 19*

### Carbide Tools

Centers, boring bars, replacement tips, drills for hardened steel, diamond wheels, milling cutters, slitting saws and many other carbide tools are described in catalog No. 956. Over 700 tools are detailed. 50 pages. Nelco Tool Co.

*Circle 510 on page 19*

### Plastic Rods & Shapes

Physical properties, available sizes and typical applications for Plexiglas and Lucite acrylic rods, tubes and shapes which are stocked for immediate delivery are listed in illustrated bulletin. This clear plastic has "light piping" and other unusual optical properties. 4 pages. Ace Plastic Co.

*Circle 511 on page 19*

### Instrument Components

Engineering data on components for use in the electronic and instrumentation fields are contained in catalog No. 11. Stock precision parts include shafts, gears, pins, assemblies, mounting plates, breadboard and differential kits, speed reducers, couplings and fasteners for use in servo, instrumentation and development work. 132 pages. PIC Design Corp.

*Circle 512 on page 19*

### Detachable Sheaves

The "Fort Worth Standardized QB Sheave Specification Guide" lists 739 stock sizes of quick-detachable sheaves ranging in diameter from 3.4 in. to 6 ft. Data are given on sheaves for A and B, C and D-section V-belts. Ask for catalog section 83-A. 16 pages. Fort Worth Steel & Machinery Co.

*Circle 513 on page 19*

### Subminiature Meters

Illustrated data sheet 230 describes a new line of 1-in. round flush-mounting panel meters which incorporate a miniaturized D'Arsonval movement. Accurate types are offered for indicating microamperes, milliamperes, millivolts and volts. 2 pages. International Instruments Inc.

*Circle 514 on page 19*

### High Vacuum Pumps

"Stokes Microvac Pumps for High Vacuum" is a guide book to pump details which contains tables of formulas, constants and conversion factors relating to vacuum processing. Solutions are given to pump problems for typical vacuum systems. Applications for high vacuum processing are discussed. 28 pages. F. J. Stokes Corp.

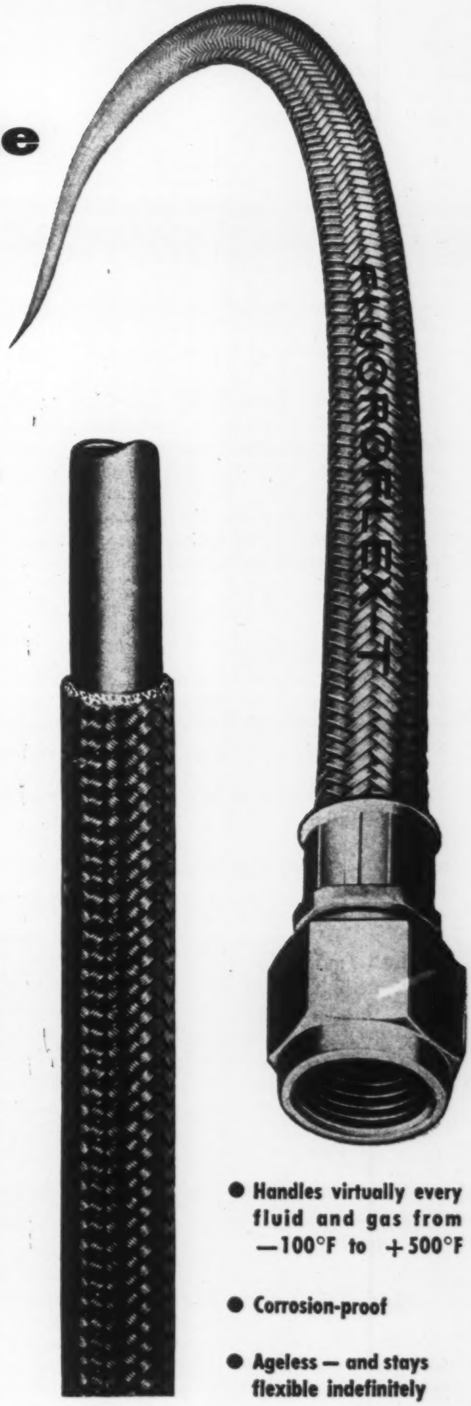
*Circle 515 on page 19*

### Static Control Elements

How static controls operate without moving parts and how they cover the logic function concept, as well as logic functions, circuit characteris-

# HOSE PROBLEMS?

## You need this TEFLON® hose



SOLVE your really tough jobs for flexible hose with *Fluoroflex®-T hose assemblies* — the original Teflon hose now proved by over 3 years of demanding service.

With tube made from a patented, special compound of Teflon, the hose is completely inert to the most corrosive chemicals, active oils and fuels, gases, all hydraulic fluids. No swelling, erosion or restriction of tube.

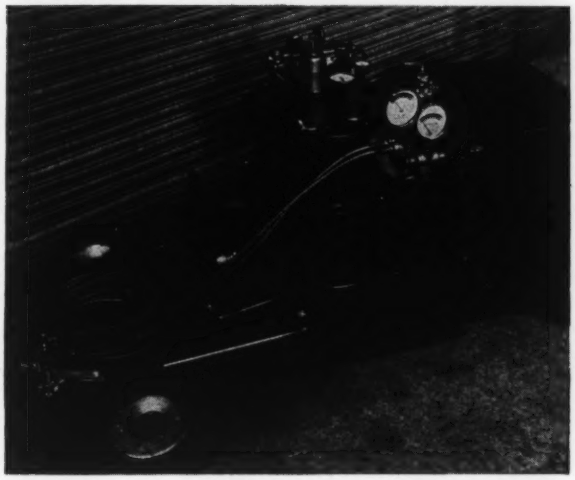
SAE 304 stainless steel braid reinforces for 1000 psi service (higher in some cases) and maintains this strength by its corrosion resistance.

Permanent, swaged fittings give positive protection against leakage and blowoff.

These lightweight, space-saving hose assemblies solve tough problems, increase reliability, cut replacement costs. Made by the originator of Teflon hose — the one company that makes its own Teflon tubing as well as hose assemblies. For more data, write RESISTOFLEX CORPORATION, Roseland, N. J.; Western Plant: Burbank, Calif.

*® Teflon is a DuPont trade mark. Fluoroflex is a Resistoflex trade mark.*

**OVER 2 YEARS' TROUBLE-FREE OPERATION:** With this airless spray equipment, industrial finishes and strong solvents are sprayed hot, at 500 to 600 psi. Fluoroflex-T hose has set a service record of over 2 years with no failures.



- **Handles virtually every fluid and gas from —100°F to +500°F**
- **Corrosion-proof**
- **Ageless — and stays flexible indefinitely**

**20th year of service to industry**

**Resistoflex**

tics, monitor lights and amplifiers are discussed in bulletin GEA-6578. Fundamentals and features of general-purpose static control logic elements are covered. 8 pages. General Electric Co.

*Circle 516 on page 19*

### Printing Calculator

In addition to describing the operation of the model 99 printing calculator, manual C1053 No. 9 explains procedures to be used in engineering departments for solving mathematical problems. Other office applications of this machine are covered. Sperry Rand Corp., Remington Rand Div.

*Circle 517 on page 19*

### Greases

Applications and specifications of Prestige 40 series of premium greases are given in bulletin 50. This grease is suited for service involving water or high temperatures. 2 pages. Sun Oil Co.

*Circle 518 on page 19*

### Synchronous Motors

Design and performance data on Synduction motors are given in bulletin 51B8440A. This synchronous induction machine provides constant speed for industrial applications requiring less than 40 hp. Variable speed operation is possible by using variable frequencies in speed range from 200 to 10,000 rpm. 4 pages. Allis-Chalmers Mfg. Co.

*Circle 519 on page 19*

### Research Facilities

In addition to complete production plants, this company has facilities for research, development and testing of electronic, electro-mechanical, optical, data reduction and transmission, control and guidance, calibration, infrared, communication and navigation systems and components. Details of facilities are given in bulletin "Men and Machines". 4 pages. Servo Corp. of America.

*Circle 520 on page 19*

### Silicon Transistors

Two production types of silicon transistors which meet the rigid requirements of Navy specifications are announced in bulletin DL-S 635. Performance characteristics are listed. 4 pages. Texas Instruments Inc.

*Circle 521 on page 19*

### Sealed Miniature Switches

Catalog No. 5 is devoted to information on miniature hermetically-sealed switches for standard and special applications. This handy idea folder contains specifications, schematic drawings and application details. Haydon Switch Inc.

*Circle 522 on page 19*

### Tube Cap Connectors

New tube cap connector designs for airborne and missile equipment as well as for electrical and electronic equipment tubes are described in illustrated guide book for electronic design engineers. 18 pages. Alden Products Co.

*Circle 523 on page 19*

### Porcelain Insulators

Screw type wire holders, house brackets, spools, split and solid knobs, tubes, cleats, antenna and guy strain insulators, telephone knobs and pipe thread bushings are among the many porcelain insulators described in illustrated catalog. 8 pages. Universal Clay Products Co.

*Circle 524 on page 19*

### Electric Motors

Condensed engineering and performance data on commonly used electric power drives are contained in condensed catalog. Prices and selection information are included on normal speed motors, geared motors, variable speed drives and speed reducers. Tables simplify drive selection. 20 pages. Sterling Electric Motors, Inc.

*Circle 525 on page 19*

### Film Type Heaters

Solutions to difficult heating problems due to odd contour shapes, space or weight limitations are described in series of folders. Series points out advantages of Electrofilm sprayed-on film type heating elements which weigh 1/10-lb per sq ft and are 0.015-in. thick. Electrofilm, Inc.

*Circle 526 on page 19*

### Flexible Metal Hose

Design suggestions for planning flexible metal connector applications are provided in catalog G-560 on flexible metal hose and tubing. Specifications, bend diameters, lengths, types, construction diagrams and descriptions of end fittings are included. Hose is offered in bronze, brass, steel, stainless, aluminum, Monel, nickel and plastics, 64 pages. American Brass Co., American Metal Hose Div.

*Circle 527 on page 19*

### Screw Machine Products

Typical Allmetal screw machine work in a variety of alloys, including stainless steel, Inconel, nickel and titanium, is shown in new folder. Fabrication operations and techniques required for each of eight items are described along with dimensions and tolerances. 4-pages. Allmetal Screw Products Co.

*Circle 528 on page 19*

### Freewheeling Clutches

Comprehensive manual covers automatic freewheeling clutches, combination clutch-couplings, backstops to prevent reversed runaway of inclined conveyors or vertical elevators, and enclosed freewheeling clutch units for continuous operation. Manual contains 110 large illustrations. 76 pages. Marland One-Way Clutch Co.

*Circle 529 on page 19*

### Corrosion-Resistant Motors

Series 254-U All-Weather rerated motors descriptively covered in bulletin 520 feature special corrosion-resistant steel housing which affords protection against all adverse weather conditions. Integral metal and cast iron parts are also given an anticorrosion treatment. 8 pages. Robbins & Myers, Inc.

*Circle 530 on page 19*

### Teflon Tape

Use of Temp-R-Tape, a pressure-sensitive Teflon tape, for Class H insulation and nonstick-facing is described in pocket-size folder. Tape is available in 0.006 and 0.013-in. thicknesses, ¼ to 12 in. wide, in rolls or on cloth backing. 4 pages. Connecticut Hard Rubber Co.

*Circle 531 on page 19*

### Levelers

Bulletin 564 describes three types of levelers for movable office partitions, electronic and office equipment, air conditioners, display cases, appliances and process equipment. Featured style FB has thick neoprene pad for vibration absorption. 4 pages. Ohio Nut & Bolt Co.

*Circle 532 on page 19*

### Embossed Metals

Nineteen embossed metal patterns are illustrated in folder along with maximum lengths and width information. 6 pages. Croname Inc., CroRoto Div.

*Circle 533 on page 19*

### Stripped Pumps

Tuthill stripped pumps for built-in lubrication, hydraulic, coolant, liquid transfer and circulating service are subject of catalog 106. Pumps are rotary, internal-gear, positive dis-

## Control Problems ? . . . Consult CONTROL EXPERTS

- Utilities
- Textiles
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- Rubber
- Petroleum
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- Metal Producing
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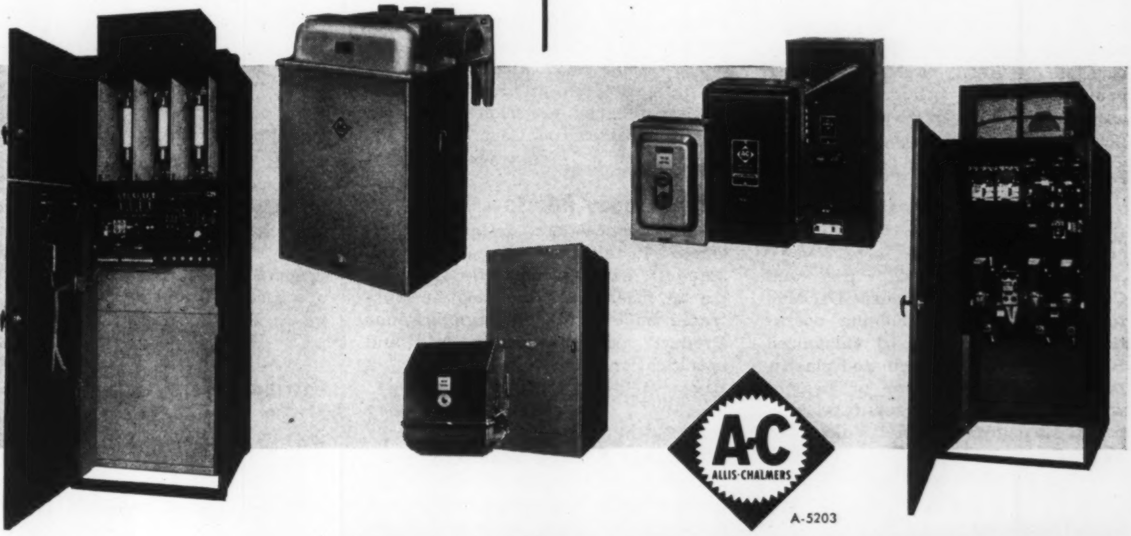

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A-5203

**ALLIS-CHALMERS**

*Circle 443 on page 19*

placement type and range in capacities up to 200 gpm at 0 psi. 12 pages. Tuthill Pump Co.

*Circle 534 on page 19*

### Investment Casting

"Design—with Microcast in Mind" is title of brochure which outlines the steps involved in investment casting and shows the wide range of intricate parts that can be mass produced by this method. It includes the most recent table of properties of investment cast alloys. 12 pages. Austenal Laboratories, Inc., Microcast Div.

*Circle 535 on page 19*

### Four-Way Air Valves

Three new models added to Allenair line of ¼, ⅜ and ½-in. four-way air valves are available as single solenoid, or foot or cam operated units. Valves operate on 5 to 150 psi. Solenoid units will reciprocate at 800 strokes per minute. Details are provided in well illustrated catalog V-103. 8 pages. A. K. Allen Co.

*Circle 536 on page 19*

### Fluid System Specialties

Parker fluid system specialties shown in catalog 4395 include clips for support of tube lines, dual heat transfer coil for cooling applications, pressure snubber for protection of gages and manifold valve to simplify draft gage line blow out. 4 pages. Parker Appliance Co., Tube & Hose Fittings Div.

*Circle 537 on page 19*

### Aircraft Hose Products

Engineering data pertaining to Aeroquip low, medium and high pressure hose assemblies with detachable, reusable fittings and self-sealing couplings, flange fittings and elbow assemblies are given in Aircraft Catalog 101. Latest medium-pressure Teflon hose is included. Aeroquip Corp.

*Circle 538 on page 19*

### Fiber & Plastic Parts

Booklet "Fabricated Parts and Components . . . Management Decision for Profit" shows machining operations and parts made of vulcanized fiber and Phenolite laminated plastic. It points up economies of dealing with a single source for fabricated parts. 12 pages. National Vulcanized Fibre Co.

*Circle 539 on page 19*

### Autotransformers

Portable, motor drive, enclosed and ball bearing models of the Variac continuously - adjustable autotransformer are cataloged in form 424-O. Duratrak contact surface applied by electroplating process using special silver alloy eliminates oxidation problems. 24 pages. General Radio Co.

*Circle 540 on page 19*

### Plated Wire

Specifications and characteristics of Nickelply and Brassply electroplated steel wires are provided in bulletin K-10. Nickel and brass coating will not separate from base metal under severe twisting, forming or redrawing operations. 8 pages. National-Standard Co.

*Circle 541 on page 19*

### Flexible Couplings

Torsionally flexible Morflex standard, double and radial couplings are described with complete dimensions and specifications in catalog C 41-56. Morflex principle employs preloaded rubber biscuits as flexible medium. 24 pages. Morse Chain Co., Industrial Sales Div.

*Circle 542 on page 19*

### Motor Selection

Information on how to select alternating-current motors for specific applications is given in motor selector bulletin B-2103-1. Data cover frame sizes from 182 to 6085. Glossary of motor enclosure terminology is included. 12 pages. Reliance Electric & Engineering Co.

*Circle 543 on page 19*

### Hermetic Compressors

Field serviceable hermetic compressors for use in packaged chillers, air conditioners and commercial refrigeration units are subject of bulletin C-1100-B93 P. Available in 2 to 7½ hp sizes, compressors are machined of interchangeable precision parts. 4 pages. Worthington Corp.

*Circle 544 on page 19*

### Screw Thread Inserts

Performance data, design relationships, installation procedure and standard size data on Heli-Coil screw thread inserts are included in illustrated bulletin 748. "Designing Your Product" contains design data and specifications for cutting costs. 4 pages. Heli-Coil Corp.

*Circle 545 on page 19*

### Stampings & Deep Drawings

Design and ordering information on stampings and deep drawings is found in illustrated brochure. Some difficult design problems are shown, and materials, tooling, time requirements and operations are discussed. 6 pages. Stanley Works, Stanley Pressed Metal Div.

*Circle 546 on page 19*

### Aircraft Heater Controls

Eight different configurations of aircraft heater controls and a rate-of-rise control are described in bulletin MC-131. Temperature range, current ratings, physical dimensions and mounting methods are covered. 4 pages. Fenwal Inc.

*Circle 547 on page 19*

### Spring Design & Selection

Fundamentals of spring design are presented in sufficient detail to guide the designer through initial stages of a design problem in illustrated brochure "Spring Design and Selection—in Brief." Basic formulas, commonly used materials, typical applications and limitations are covered. 8 pages. Associated Spring Corp.

*Circle 548 on page 19*

### Machinery Mounts

Elasto-Rib vibration and noise absorbing machinery mounts are described in illustrated bulletin K2D. Material properties and those of Universal Dampers incorporating the material are detailed. Capacity tables are included. 2 pages. Korfund Co.

*Circle 549 on page 19*

### Shell Molding Resins

"Plaskon Resins for Shell Molding" is illustrated booklet which describes the process, design and production considerations, available types of molding machinery, production techniques, special metals handling and sand reclamation, among other subjects. 32 pages. Allied Chemical & Dye Corp., Barrett Div.

*Circle 550 on page 19*

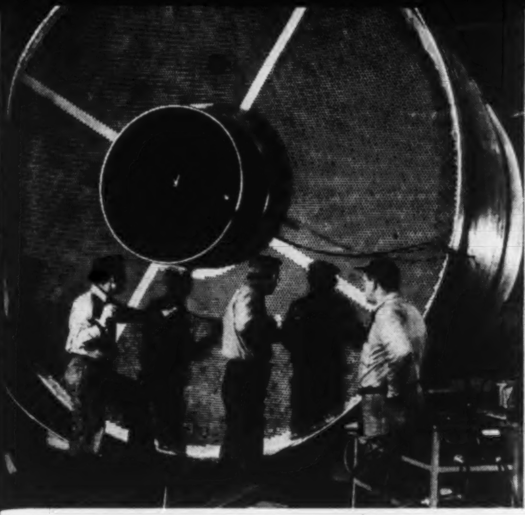
### Iron Powders

Iron powder with CDF (controlled dimensional factor) is subject of illustrated bulletin 763. Advantages and characteristics of each type of powder and curves for their various properties are included, along with specifications and design pointers. 16 pages. Republic Steel Corp.

*Circle 551 on page 19*

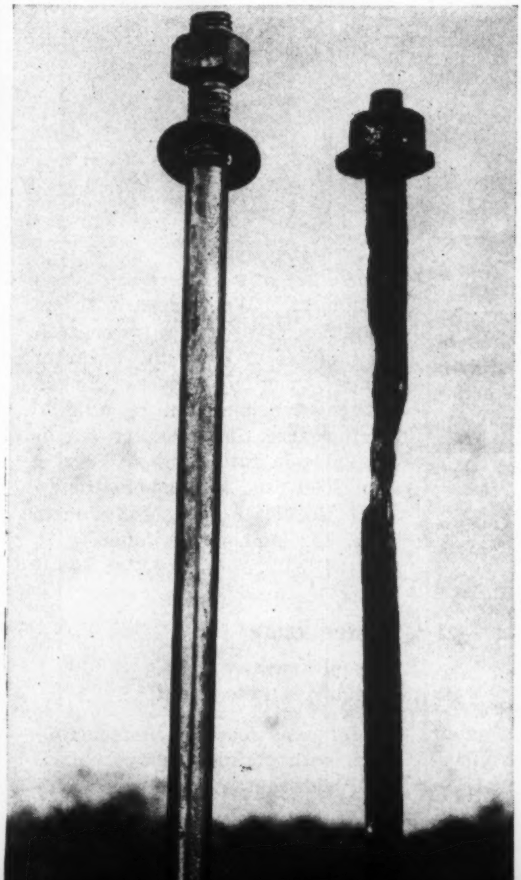
### Casting Buyers' Guide

Lists of sources for gray iron castings in every industrial area are contained in Buyers' Guide and Directory. Data for each foundry includes type and size of castings produced, average production and executive personnel. Request from Gray Iron Founders' Society, Inc., National City-East Sixth Bldg., Cleveland 14, O.



**FOR HIGH TEMPERATURE STRENGTH.** This looks like a sieve, but actually it is a Stainless Steel plate punched with 25,400 holes, and it makes up the end plate of a chemical plant heat exchanger. After the tubes were inserted the exchanger was placed in high-temperature, intensely corrosive 24-hour service. It was made by the Nooter Corporation, St. Louis.

**FOR CORROSION RESISTANCE.** Rare Earths, Inc., produces such valuables as cerium, lanthanum and praseodymium by means of an elaborate chemical separation process. In the filter press, corrosion destroyed carbon steel plate rods in six months. Stainless Steel rods were installed over six *years* ago, and are still in fine condition.



# NOTHING *can equal* *Stainless Steel*

*for its combination of desirable properties*

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When seeking a source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

**FOR TAKING A BEATING.** These are 8th grade students from Dormont, Pa., public schools in a domestic science class. The sink tops were made by Pride Mfg. Co., Pittsburgh, from USS Stainless Steel. Says Pride, "These Stainless sink tops are ideal for school use. We've seen some 20-year-old sinks that still look as good as new."

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL

*Circle 444 on page 19*

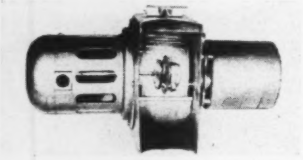
# New Parts and Materials

Use Yellow Card, page 19, to obtain more information

### Centrifugal Switch

**withstands**
**1 million cycles**

Syncro-Snap centrifugal switch operates on frictionless, snap-action principle that eliminates all wear associated with fly-ball spring-pivot governers. Typical application is installation in blower for gas furnace where switch stops gas flow in case of blower failure. In this case, switch is mounted on blower shaft and operates in conjunction with mercury switch. Accuracy is ±3 per cent of rotational speed. Switch provides operating life in excess of 1 million cycles. **Torq Engineered Products Co.,** Interstate St., Bedford, Ohio.

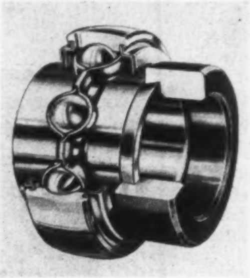


*Circle 552 on page 19*

### Ball Bearing

**wide inner ring unit**
**has effective seal**

Self-aligning, sealed, wide inner ring ball bearing seals out contaminants at slow to moderate speeds and retains supply of grease. Seal consists of two dished steel plates surrounding a synthetic rubber impregnated fabric sealing washer. Both plates are fixed in outer ring; inner plate provides backing for seal washer and baffle for grease retention. Outer plate permits seal to flare out in wiper fashion, insuring tight contact with inner ring. Bearing is available either relubricatable or nonrelubricatable in pillow block or two types of flange mountings. Size range is ½ to 2 15/16 in. bore, 1.575 to 5.118 in. OD, and 1 15/16 to 3⅝ in. overall width. **Fafnir Bearing Co.,** 37 Booth St., New Britain, Conn.

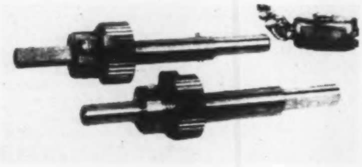


*Circle 553 on page 19*

### Clutches

**miniature units are**
**available in three types**

Clutches are available in three types and are designed to disengage a particular subassembly from an entire system, either to render that portion inoperative when it is no longer required or to protect it from overload. Friction clutch provides clutch action at predetermined torque and can be set to stop at any torque from 2 to 20 in.-oz. Single drive magnetic clutch is used to electrically connect or disconnect linkage at predetermined torque or previously set stages in operational sequence. Reversing magnetic clutch is used either as a reversing clutch or as a two-speed drive. Maximum power requirement of both magnetic units is 30 v, 27 amp; output torque is 40 in.-oz. **Servo Corp. of America,** 20-20 Jericho Turnpike, New Hyde Park, N. Y.



*Circle 554 on page 19*

### Servo Valve

**gives variable**
**flow control**

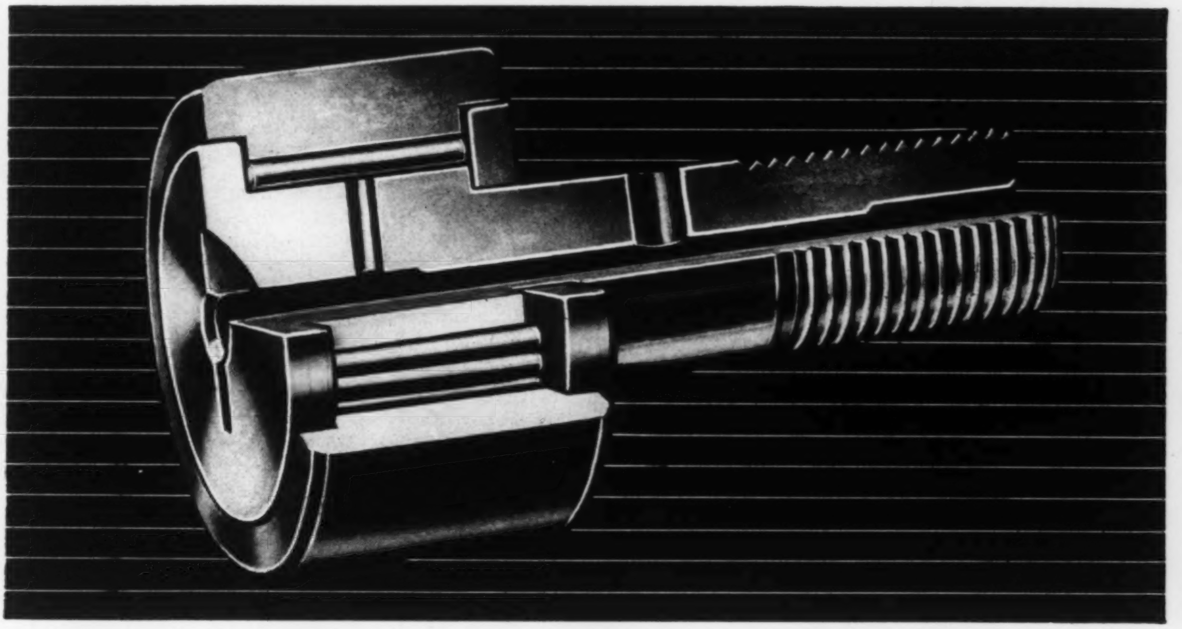
Electro - hydraulic servo valve allows hydraulic control of variable delivery pumps, hydraulic motors, cylinders and similar equipment. When used with an amplifier, three-way valve controls flow of oil to hydraulic linear or rotary - motion drives. Single-stage valve is driven by a high-performance torque motor and is available in ratings up to 10 gpm and 3000 psi. **Minneapolis-Honeywell Regulator Co.,** 2753 Fourth Ave. So., Minneapolis, Minn.

*Circle 555 on page 19*

### Meter Relay

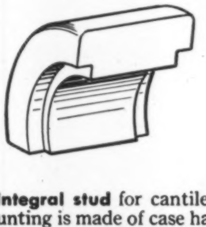
**supersensitive unit**
**controls up to 1 watt**

Meter relay features simplified design with platinum alloy contacts and high contact force which mini-



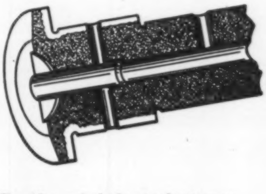
# TORRINGTON CAM FOLLOWERS

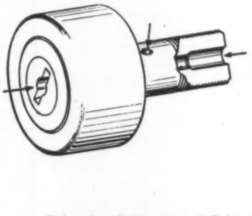
## Give Longer Service . . . Carry High Shock Loads



**1. Heavy sectioned outer race** of hardened and ground high carbon chrome steel assures uniform distribution of high rolling and shock loads while providing high capacity anti-friction performance.

**2. Integral stud** for cantilever mounting is made of case hardened and ground low carbon nickel molybdenum steel. The tough core provides high strength to withstand high shock loads.

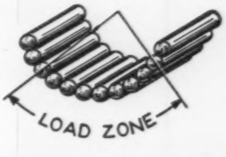


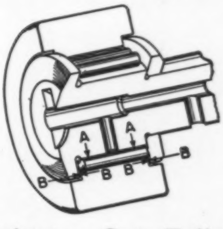


**3. Easily relubricated** at any one of three points—at either end or through cross hole in stud. Ends accommodate standard drive grease fittings, or may be sealed by the plugs provided.

*District Offices and Distributors in Principal Cities of United States and Canada*

**4. Full complement** of small diameter rollers—through-hardened, ground and lapped—for maximum radial load capacity.





**5. Raceways precision ground** for even load distribution (A) and uniform low end play (B) assure long bearing life.

Torrington Cam Followers are precision made throughout. They are available in sizes from ½" to 2¼" O.D. Special surface finishes such as chrome and cadmium plate or oxide black can be provided.

Our Engineering Department will be glad to work with you in adapting these dependable and efficient Cam Followers to your cam-controlled or track-type equipment. Torrington Cam Followers give better service because they're better made.

THE TORRINGTON COMPANY
**Torrington, Conn.** **South Bend 21, Ind.**

# TORRINGTON BEARINGS

THE TORRINGTON COMPANY 90th ANNIVERSARY 1866-1956

**Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers**

*Circle 445 on page 19*

XUM

mizes sticking and provides a high degree of reliability. Operating on power input of less than 50 millimicrowatts, relay will control up to 1 watt; power amplification is 20 million. Meter Relay is nonlocking type available in ac and dc models as microammeters, milliammeters, ammeters, millivoltmeters and voltmeters. Pyrometer type with bimetal compensation is also available. Four contact arrangements can be supplied. **Simpson Electric Co.,** 5200 W. Kinzie St., Chicago 44, Ill.

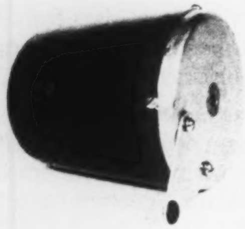
Simpson
METER RELAY
A.C VOLTS

*Circle 556 on page 19*

## Gear Motor

**shaft-mounted unit has wide range of speeds**

Shaft-mounted gear motor provides remote and automatic control for variable speed drives, valves, pumps, feeders and similar machines. Unit mounts on shafts from ¼ to ⅞-in. diam and is light and compact. Both housing and cover are aluminum. Torque arm has resilient mounting to absorb any runout that may be present in shaft being controlled. When used on rising stem valves and similar applications, torque arm is equipped with linear bushing to allow axial movement. Unit may be mounted either horizontally or vertically with shaft up or down. A wide range of output speeds and torque capacities is available. Single-phase unit has instantly reversible, permanent-split capacitor motor for high starting torque. Larger units are three-phase. Explosion proof and other enclosures are available. **Jordan Co. Inc.,** 3235 W. Hampton Ave., Milwaukee 9, Wis.

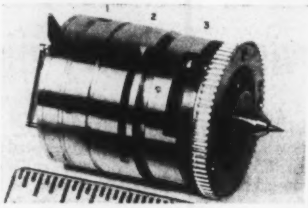


*Circle 557 on page 19*

## Timing Mechanism

**miniature unit provides time intervals to 168 hr.**

Timer is built on a modular principle which permits extremely wide range of timing intervals and mechanical or electrical control functions. Unit is composed of three cylindrical cartridge units, each 1¼ in. diam. One module houses a mainspring to provide mechanical driving power for operating entire unit. Second module houses time measuring mechanism, and third module houses the control unit which contains a cam driven by the power unit at a rate controlled by the timing mechanism. Unit can open or close an electrical circuit at desired intervals or provide a mechanical impulse. Time interval range is from a few seconds to 168 hours with accuracy of ±1 per cent from $-65$ to 165 F. Unit will withstand accelerations of 3000 $g$ for 10 milliseconds and has only slight reduction in accuracy when rotated upon its own axis at high speeds. **Hamilton Watch Co.,** Allied Products Div., Lancaster, Pa.



*Circle 558 on page 19*

## Rubber Belting

**has cord interliner to prevent stretching**

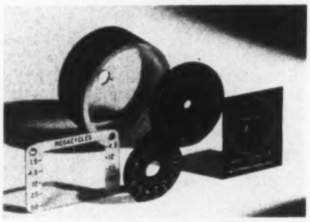
Seamless rubber belt for drive and feed-belt applications is nonstretching. Straight-line cord interliner, vulcanized between two layers of tough synthetic rubber, maintains unchanging length and eliminates possibility of slippage in applications where a positive drive must be held constantly. Belt has unusual flexibility, allowing use for such duties as drive belts on dictating machines, tape recorders, industrial pumps and compressors, or as feed belts on packaging machines, duplicating machines, and postage meters. Belts can be made in many lengths, widths, and thicknesses in almost any type of rubber including nitrile, styrene, neoprene and natural rubber or in combination. Rubber compounds have high surface friction for excellent power transmission and are resistant to oils, solvents, ozone cracking, and changes in humidity. **Armstrong Cork Co.,** Lancaster, Pa.

*Circle 559 on page 19*

## Instrument Dials

**produced with exceptional accuracy**

Precision instrument dials have accuracy to 2 min of arc and graduations concentric to locating holes within 0.0005-in. TIR. A master is engraved on optical flat glass and dials are reproduced photographically, enabling reproduced dials to have sharp graduations as fine as 0.002-in. Process is suited for both short and long production runs. Dials are produced on metals and plastics such as aluminum, brass, steel, lamicoid and plexiglas. Plastic parts may be opaque, transparent, or translucent for back and edge-lighting effects. **Ackerman Engravers,** 458 Broadway, New York 13, N. Y.

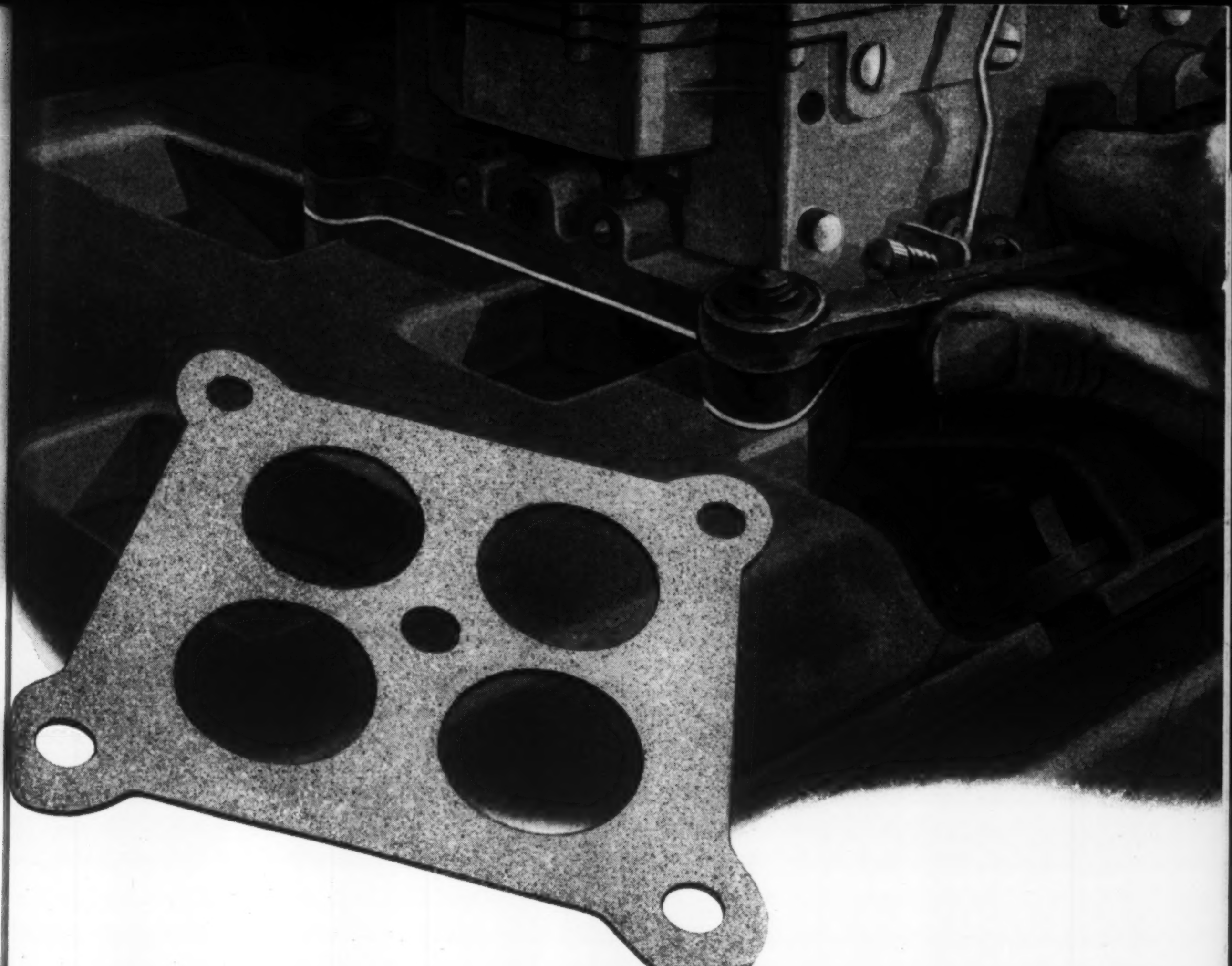


*Circle 560 on page 19*

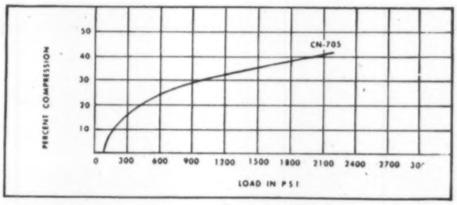
## Press Nut

**provides flush mounting in pre-pierced hole**

Sheet metal nut has thread-size range from No. 2 through No. 10. Nut fastens securely in sheet metal, offering flush mounting with



Accopac® fiber gasket seals tightly at flange pressures as low as 800 psi



LOAD-COMPRESSION CURVE SHOWS high compressibility of Armstrong CN-705 Accopac. This compressibility allows gaskets to seal under light bolt pressures normally available with light flanges.

Armstrong CN-705 Accopac—an improved fiber gasket material—becomes impervious to both liquids and gases at flange pressures as low as 800 psi. This means that CN-705 is ideal for use in lightweight metal assemblies, where low bolting pressures are necessary.

The secret of Accopac's great sealability lies in its manufacture. It's made by a special beater-saturation process that locks cellulose fibers and springy cork particles in a non-extractable nitrile latex binder. This produces a material with both high compressibility and excellent "kickback."

Because its binder is non-extractable, CN-705 will never shrink or dry out—in storage or on the flange. It keeps a tight seal even in alternately wet and dry applications.

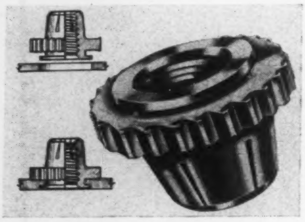
For more facts about CN-705 Accopac, write Armstrong Cork Company, 7012 Dean Street, Lancaster, Pennsylvania.

Armstrong ACCOPAC

*. . . used wherever performance counts*

Circle 446 on page 19

sheet thickness as low as 0.035-in. Design configuration locks nut in sheet both radially and axially. Nut is 303 stainless steel or Ledloy steel and meets AN-N-5 and AN-N-10 specifications. Installation is quick and simple, requiring only a hole in the sheet into which the nut is pressed. **Rosan Inc.,** 2901 W. Coast Hwy., Newport Beach, Calif.

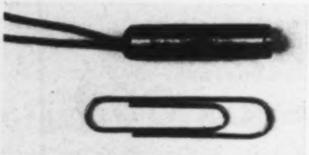


Circle 561 on page 19

### Miniature Thermostat

**operates repeatedly on $\frac{1}{8}$-F differential**

Subminiature thermostatic switch is only $\frac{1}{4}$-in. OD by 1 in. long. Uses are for precision temperature control in cathode tubes and other special and general applications. Available in plain, flanged or screwed head mounting, switch has either two-wire or grounded type construction. Rated load is 1 amp, 110 v ac. Operating ranges are 50 to 175 F, 150 to 275 F, or 250 to 275 F. Unit operates repeatedly on differential of $\frac{1}{8}$-F between make and break setting. **Scaico Controls Inc.,** Palmyra, N. J.

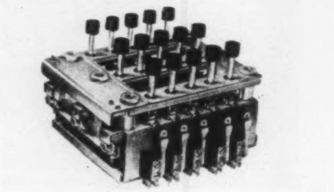


Circle 562 on page 19

### Interlocking Switch

**has up to 36 pushbutton switches**

Interlocking pushbutton switch, mounted in parallel row assemblies to provide a maximum number of interlocked stations, is available in two types. Series 5900, illustrated, is available with up to 36 interlocking stations; Series 5700 has a maximum of 24 stations. Each station may be equipped with various contact combinations rated 3 or 5 amp, 110 v ac noninductive. In operation, each button depressed releases any previously operated station and locks itself in the operated position. Features include a lock-out to prevent operation of more than one station at a time, solenoid release, and nonlocking stations. **Donald P. Mossman Inc.,** Brewster, N. Y.



Circle 563 on page 19

### Plastic Adhesive

**for automatic sealing of films**

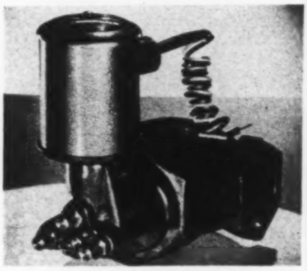
Hot-melt adhesive in coil form is called Thermogrip. Thermoplastic adhesive is designed for application with a feeding and melting device that can be attached to packaging or similar machinery for high-speed bonding of polyethylene films, foils, glassine, and other types of boards and papers. Adhesive eliminates clean-up, premelting and offers time advantages over manual application. Instant bond permits immediate secondary operations and combining of operations without slippage. **United Shoe Machinery Corp.,** 140 Federal St., Boston 7, Mass.

Circle 564 on page 19

### Solenoid Valve

**has independent manual adjustments**

Solenoid valve provides independent controls for manual opening, adjustment of flow, and variation in opening and closing speeds. Known as Type HV, valve may be mounted at any angle. Available in sizes from $\frac{1}{2}$-in. to 2 in., valve has maximum capacity of 300 psi. Four independent controls are grouped in a cluster for convenient adjustment. Closing and opening adjustments are independent and have no effect on each other. Manual opening stem allows operation in case of power failure. **J. D. Gould Co.,** 4707 Massachusetts Ave., Indianapolis 18, Ind.



Circle 565 on page 19

### Timing Motor

**has speed range of 0.8 to 2 rph**

Small timing motor has speed range of 1 rpm to 1 rph without extra gearing. Motor is rated at 20 oz-in. at 1 rph and is for use in switches, timers and control applications. Unit has lifetime lubrication, is completely enclosed, and is available with optional one-way or two-way clutch. Speeds of motor are 0.8 to 120 rph at 60 cycle, 0.8 to 100 rph at 50 cycle, and 1 to 2 rph at 25 cycle. **Hansen Mfg.,** Princeton, Ind.

Circle 566 on page 19

### Rubber Compound

**has nonsticking characteristics**

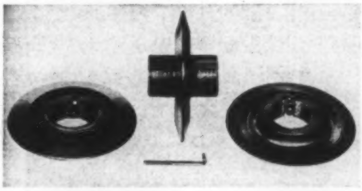
Rubber compound has outstanding nonsticking properties, making it ideal for valve seat and similar applications. Known as Compound No. 1318, material has excellent metal-bonding properties, yet gives quick break-away without lubrication. Recommended temperature range of applications is −40 to 300 F. **Goshen Rubber Co. Inc.**, Box 517, Goshen, Ind.

*Circle 567 on page 19*

### Adjustable Sheave

**has increased power capacity**

One and two-groove sheaves, for quick, easy speed adjustment for A and B section V-belt drives, are designed for low-power applications and provide increased maximum design power. Sheave, which is same size as standard, two-groove, B-section adjustable-pitch sheave, handles approximately three times more power. Keys transmit all torque from shaft to hub and hub to disks. Set screw and key give positive lock between movable disks and stationary hub. Sheave illustrated is a two-groove unit. Outer flanges may be adjusted to proper distance from flange on hub to give belt pitch diameter desired. Sheaves for A section belts have 1 in. of PD adjustment; B section belt sheaves have 1.2 in. Horsepower range at 1750 rpm is 1.39 to 6.50 per belt. **Allis-Chalmers Mfg. Co.**, 1126 S. 70th St., Milwaukee 1, Wis.



*Circle 568 on page 19*

### Insulating Varnish

**has high heat resistance**

New Class B insulating varnish is a polyester type material known as Isonel. Varnish has heat resistance similar to Class B wire enamels and handling and curing characteristics adapted to cycles and temperatures currently used by electrical manufacturers. Aging tests show that material has two to eight times life of Class A varnishes when aged at 200 C and subjected periodically to a 2000 v

YOU WOULDN'T BUY
A HAT THAT'S TOO BIG!

SO WHY BUY A **Control** THAT'S THE WRONG SIZE?

FURNAS
MAGNETIC
CONTROLS
GIVE YOU
CORRECT
CAPACITY
FOR
THE JOB!

The many in-between sizes in the Furnas Electric starter line let you select the motor control that is best suited for your particular requirements—with no wasted capacity and expense. By matching the starter to the job you can *save up to 25%*. For proof, we invite your comparison of the Furnas Electric line of starters consisting of 9 sizes with the 5 sizes normally offered.

And you can *save up to 40%* in space by securing the correct size starters for the job, Furnas Electric produces more stock sizes of starters in the 1-100 hp range than other control manufacturers.

SERIES YD
SIZE 1

SERIES YE
SIZE 1¾

SERIES YF
SIZE 2

A15

FURNAS

FURNAS ELECTRIC COMPANY
BATAVIA ILLINOIS
SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

WRITE FOR BULLETIN 5530—1045 McKEE STREET, BATAVIA, ILLINOIS

*Circle 447 on page 19*

XUM

Illustrated here is the Brunswick Automatic combination clutch and Speed Reducer.

**OHIO**
*Special*
**SPEED REDUCERS**

An Ohio Speed Reducer is the major element which makes the Brunswick Semi-Automatic Bowling Pinsetter so outstanding in its performance.

Although the motor and reducer input shaft turn constantly, power is not transmitted until the trigger trip on the actuator shaft engages the clutch for one full cycle. Stock Speed Reducers available in ratios from 1-1 to 4000-1. Capacities from 1/6 to 15 H.P.

**Write us concerning your power transmission and gearing requirements.**

ESTABLISHED 1915
OHIO GEARS

**THE OHIO GEAR COMPANY • 1338 E. 179th St. • Cleveland 10, Ohio**

*Circle 448 on page 19*

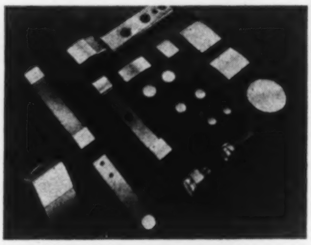
dielectric test. Varnish is completely heat reactive; at 180 C it cures to a tough, solid mass. Recommended thinner is mineral spirits; tank stability is excellent; and curing temperature is 375 to 400 F. **Schenectady Varnish Co. Inc.,** Schenectady, N. Y.

*Circle 569 on page 19*

## *Electrical Contacts*

### have high current-carrying capacity

Electrical contacts, containing silver and cadmium oxide, withstand larger currents than silver or silver-alloy contacts without welding or sticking. Gibsiloy compositions provide long life, high current-carrying capacities and increased electrical ratings. Contacts have excellent arc-quenching traits, low contact resistance, high conductivity and low material loss. Applications include motor-starting and limit switches, light and medium-duty contactors and relays, aircraft relays and industrial controls. Properties of four contact materials available offer conductivity range of 75 to 80 per cent IACS, Rockwell F hardness of 40 to 60, and density of 9.4 to 9.6. Contacts are available in disks, rectangles, irregular shapes, and rivets. **Gibson Electric Co.,** 8355 Frankstown Ave., Pittsburgh 21, Pa.

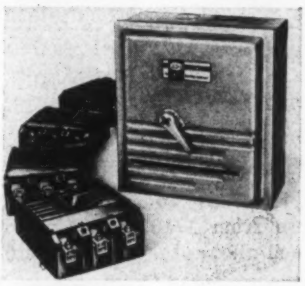


*Circle 570 on page 19*

## *Circuit Breakers*

### standardized units in two case sizes

Molded case enclosed circuit breakers and enclosures in Type E, F and J frames provide plug-in ratings from 15 to 225 amp in only two NEMA 1A general-purpose enclosures. Two additional enclosures are designed for conventional bolted-in Type K, KL and L frame breakers. Circuit breakers have stabs attached and visible disconnect safety. Down time is minimized due to ability to carry temporary light overloads. Quick-make and quick-break mechanism with deionization-type arc quenching provides long service life. Units have accurate, tamperproof calibration, positive motor protection and low power loss. **Federal Pacific Electric Co.,** 40 Paris St., Newark, N. J.

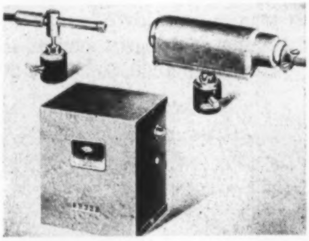


*Circle 571 on page 19*

## *Photoelectric Control*

**miniature units**
**are 3 in. long**

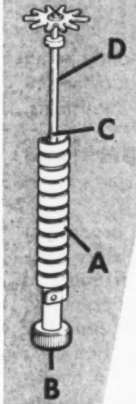
Photoelectric control has miniaturized components and features simple design, ease of installation, accuracy and dependability. Photo cell and light source units are each about 3 in. long, permitting installation in tight places and are swivel mounted for ease of installation and alignment. Cell unit uses a cadmium sulfide cell for long life and high sensitivity. Control circuits, signal lights and counter are housed in steel case which can be installed in a remote location. Unit will count up to 600 operations per minute. **Standard Instrument Corp.,** Robot-Eye Photo Control Div., 657 Broadway, N. Y. 12, N. Y.



*Circle 572 on page 19*

**HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE *Marsh* BOILER GAUGE**

A Product of James P. Marsh
Corporation
Skokie, Ill.



This neat Type 23 D S Q T boiler gauge is a product of James P. Marsh Corporation, manufacturers of temperature indicating devices for industry and the home. The Ther-Alti-Meter shows altitude and steam pressure and boiler temperature, all on one compact dial. The temperature gauge is actuated by an element made of dependable Chace Thermostatic Bimetal for accuracy and many years of continuous performance.

Here's how it works: The helical coil element of Chace Thermostatic Bimetal (A) is welded to a knurled brass plug (B) which is a press fit in the immersion tube. The free end (C) fits into the slotted end of the shaft (D) which is geared to the temperature indicator hand. The bending action of the bimetal in the coil causes the upper end to turn counter-clockwise as the temperature rises, thru rotating the shaft. The element is geared so that it rotates the indicator 180° between the range of 60° and 320° F.

**Remember Chace when you design for temperature actuation or indication, or for protection of valuable equipment. Dependable Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal and many pages of engineering data.**

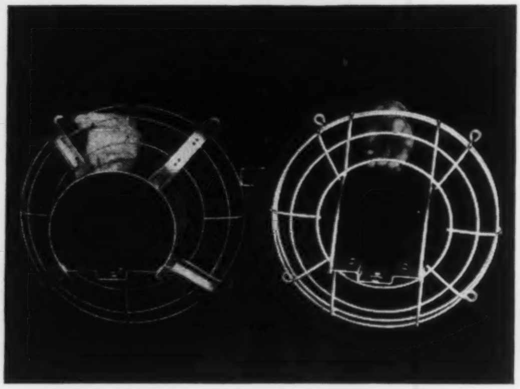
IT BENDS WITH THE HEAT

**W. M. CHACE CO.**
*Thermostatic Bimetal*
1616 BEARD AVE., DETROIT 9, MICH.

*Circle 449 on page 19*

**Most costs can be reduced!**

*Come to Titchener!*



**$1.00 PER UNIT SAVED:** This motor mount was originally comprised of two separate parts—sheet steel and wire guard. To simplify assembly and reduce unit cost, the manufacturer came to Titchener. Result: the new Titchener-manufactured motor mount, right, is a single welded-wire assembly. Strip steel is eliminated, and only one assembly step is necessary.

**Take advantage of Titchener ideas**

Costly products and parts for all types of industry are constantly being replaced by Titchener simplified components . . . with equal or improved reliability of performance . . . *at significant cost reductions.*

**We welcome the opportunity to discuss your problems with you personally.**

Visit us . . . inspect our cost-cutting facilities for volume production at first hand. Our business is to help you make your product more competitive in price and performance. If you find it impossible to come to Titchener personally, write us about your problem. Send prints or samples. You'll receive a complete cost analysis plus cost-cutting suggestions. Production quotations included. A full size sample can be made at your request. Your information remains confidential.

**A few of the many firms which have recently benefitted from a trip to Titchener:**

- Surface Combustion Corporation
- I.B.M. Corporation
- Daystrom Furniture Company
- General Electric Company

WIRE
GOODS
Headquarters

HOW
WIRE CONSTRUCTION REDUCES COSTS
E.H.Titchener & Co.

**E.H.Titchener & Co.**

61 Clinton St., Binghamton, N. Y.

**FREE . . . new booklet; "How Wire Construction Reduces Costs"**

A brand new study, "Before" and "After" illustrations of 36 products, with specific details on how Titchener suggestions enable manufacturers to cut costs and improve their product. Just mail the coupon.

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61 Clinton St., Binghamton, N. Y.
Please forward my copy of the free "HOW" booklet showing how wire redesign by Titchener cuts costs.

Name ____________________

Company ____________________

Address ____________________

City ____________________

*Circle 450 on page 19*

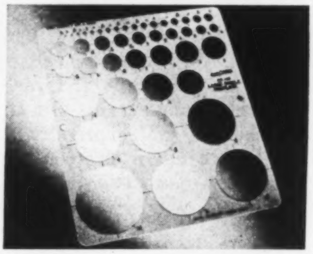
ENGINEERING DEPARTMENT

# EQUIPMENT

## *Circle Template*

**for circles to $2\frac{1}{4}$ in. diam**

Template has 45 circles with diameters from 1/16 to $2\frac{1}{4}$ in. with pencil allowance. Template is 0.030 matte-finish plastic with ink filled markings. Size is $7\frac{1}{4}$ by $8\frac{1}{4}$ in. **Rapidesign Inc.**, Box 592, Glendale, Calif.

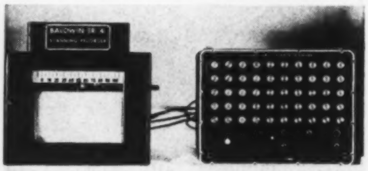


*Circle 573 on page 19*

## *Scanning Recorder*

**for strain gages gives concurrent data**

Automatic 50-point scanning recorder for SR-4 strain gages can accommodate either two-arm or four-arm strain-gage bridges by positioning of selector switch. Four ranges cover 0-1000, 0-2000, 0-5000, and 0-10,000 mu in. Individual stress-strain curves can be plotted automatically for each channel during test, providing immediate information on possible structure failure. Instrument has manual adjusting knobs for gages with resistances ranging from 60 to 500 ohms and gage factors between 1.77 and 2.25. **Baldwin-Lima-Hamilton Corp.**, Electronics and In-



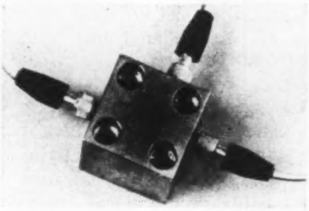
strumentation Div., 806 Massachussetts Ave., Cambridge 39, Mass.

*Circle 574 on page 19*

## Accelerometer

### subminiature unit measures three-axis accelerations

Subminiature high-temperature accelerometer measures three mutually perpendicular accelerations simultaneously. Designated Glennite Model AHT-30T, unit operates accurately in temperatures from —65 F to 350 F, has acceleration range up to 500 *g*. frequency response from 25 to 20,000 cps, and sensitivity of 0.8 mv per *g*. Unit weighs less than 1 oz and is less than 1 cu in. in volume. **Gulton Industries, Inc.,** 212 Durham Ave., Metuchen, N. J.

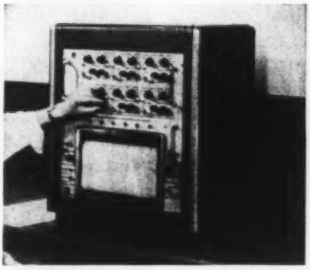


*Circle 575 on page 19*

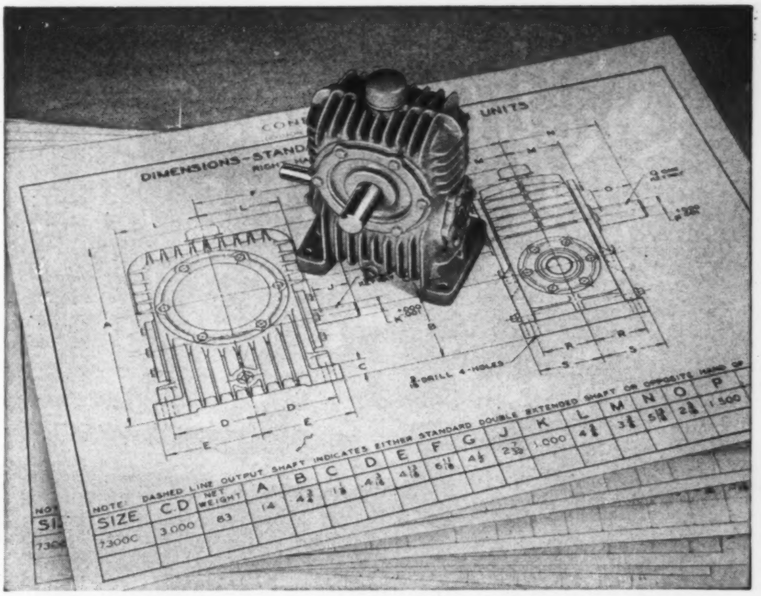
## Amplifier Unit

### has measurement range of 0.050 to 400 v

Multi-channel dc amplifier unit consists of six interchangeable plug-in dc amplifier sections, a power supply and a six-channel oscillograph. Amplifier unit has measurement range from 0.050 to 400 v, excellent zero line stability and frequency response of 100 cycles dc. **Brush Electronics Co.,** 3405 Perkins Ave., Cleveland 14, Ohio.



*Circle 576 on page 19*


DIMENSIONS-STAND
UNITS
SIZE
C.D
NET WEIGHT
A
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C
D
E
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K
L
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O
P
7300C
3.000
83
1.000
1.500
NOTE: DASHED LINE OUTPUT SHAFT INDICATES EITHER STANDARD DOUBLE EXTENDED SHAFT OR OPPOSITE HAND OF

# DIMENSIONS ONLY TELL HALF THE STORY...

. . . about worm gear speed reducers. You've got to compare size with load capacity for the whole picture. Inside a Cone-Drive speed reducer you'll find the double-enveloping worm gear design that makes it the most efficient right-angle speed reducer available.

Take the standard 3″ center distance unit above for example. Here are its Class I Service Ratings with a 5:1 reduction:

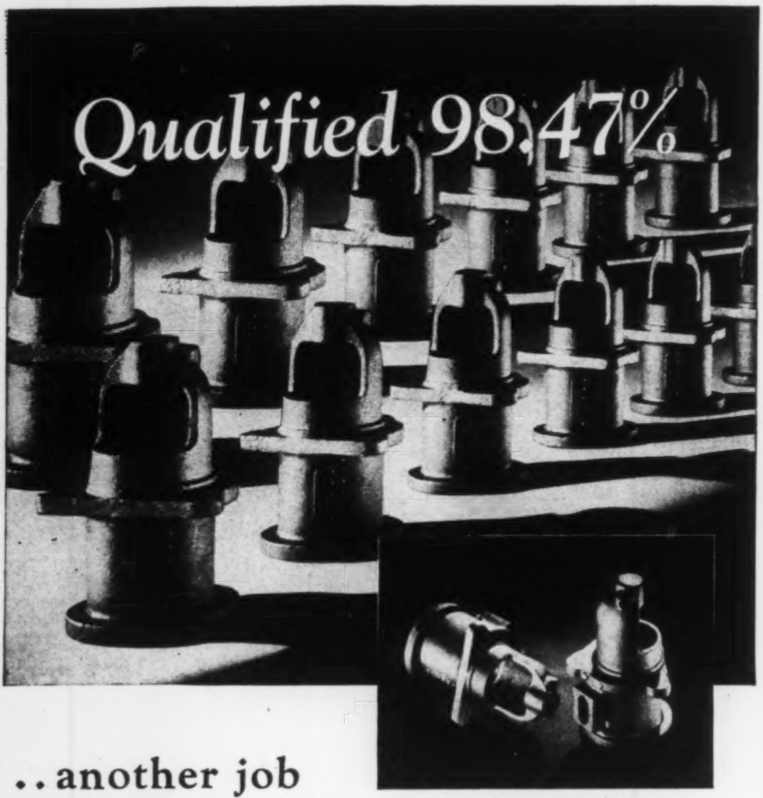
| **Worm RPM** | **100** | **200** | **300** | **580** | **720** | **870** | **1150** | **1750** |
|---|---|---|---|---|---|---|---|---|
| **Mech. HP** | 1.24 | 2.21 | 3.08 | 4.89 | 5.61 | 6.34 | 7.41 | 9.04 |
| **Thermal HP** | 1.24 | 2.21 | 3.08 | 4.20 | 4.62 | 5.10 | 6.00 | 7.80 |
| **Output Torque** (inch-lbs.) | 3340 | 3010 | 2830 | 2405 | 2250 | 2150 | 1940 | 1575 |

That's a lot of capacity for a unit that occupies less floor space than this magazine page. But it's typical of Cone-Drive speed reducers and gearsets. Complete details on this model in Bulletin 600-C. Other units to 800 HP and ratios to 4900:1.

CONE-DRIVE GEARS
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
Division, Michigan Tool Company
7171 E. McNichols Road • Detroit 12, Michigan

*Circle 451 on page 19*

XUM



..another job done better with *UNITCASTINGS!*

Faced with a problem of economically producing a starter housing that would take more than normal abuse, Unitcast engineers successfully provided the answer with *steel* castings. Previous to the use of Unitcastings, replacement costs were excessive and the need of a tougher material was imperative. Cost was also an important requisite, and by delivering *consistent* quality in conjunction with a tougher material—scrap and lost time has been held at a minimum. To date, more than 33,000 units have qualified with a higher basic cost being offset by practically no replacement and most important —a lower *finished* cost!

Take another look at the *finished* cost of your parts inventory —perhaps you *can do better with Unitcastings!* Consult a Unitcast engineer, soon!

UNITCAST CORPORATION, Toledo 9, Ohio
*In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec*

**Unitcast** QUALITY STEEL CASTINGS

Circle 452 on page 19

# THE ENGINEER'S Library

## Recent Books ②

**Pulse and Digital Circuits.** *By Jacob Millman, professor of electrical engineering, Columbia University, and Herbert Taub, associate professor of electrical engineering, City College of New York; 687 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36; available from* MACHINE DESIGN, $12.50 *postpaid.*

This text for senior and graduate college courses provides a description and an analysis of the circuits and techniques common to many fields of electrical engineering. The 18 chapters include discussions of amplifier circuits, wave-forming, linear-pulse amplifiers, multivibrators, time-base generators, oscillators, counting, digital-computer circuits, voltage comparators, and transistors.

**Applied Electrical Measurements.** *By Isaac F. Kinnard, manager of engineering, Instrument Department, General Electric Co., West Lynn, Mass; 600 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16; available from* MACHINE DESIGN, $15.00 *postpaid.*

This volume is divided into two parts. Part 1 covers the measurement of electrical quantities including current, potential difference, resistance, power, energy and magnetism. Part 2 discusses the measurement of nonelectrical quantities such as light, heat, sound, liquids, gases and time. Also included are chapters on the history, theory and functional analysis of measurement and a review of the state of applications in selected fields.

329107 ①

**A Human Engineering Bibliography.** *By Ivan N. McCollom, professor of psychology, San Diego State College, and Alphonse Chapanis, professor of psychology and industrial engineering, The Johns Hopkins University; 128 pages, 8½ by 11 in., paperbound;*

*published by and available from San Diego State College Foundation, San Diego 15, Calif.; $4.00 per copy.*

Compiled for design engineers, this bibliography lists published material in the entire field. Nearly 5700 published works are listed in 26 different categories.

## Association Publications

**Symposium on Impact Testing.** 170 *pages, 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $2.65 per copy to members, $3.50 to nonmembers.*

This book gives 14 papers presented at the 58th annual meeting of ASTM. The papers cover all phases of impact testing, including notched bar testing, Charpy impact test, impact tube test, testing methods, and results of impact testing on various materials.

**Machine Tool Electrical Standards.** 20 *pages, 8 by 11 in., paperbound, side-stapled; published by and available from National Machine Tool Builders Association, 2071 E. 102nd St., Cleveland 6; free of charge.*

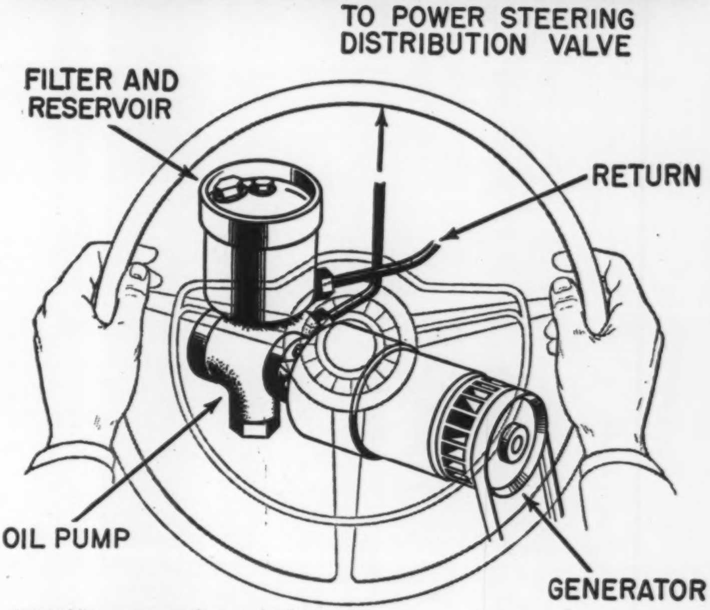
These revised standards, adopted March 1, 1956, include definitions of terms, wiring diagrams, conductors, gaskets, grounding, identification, switch interlocking, equipment mounting, circuit protection, switches and circuit breakers.

## Government Publications

**Hydraulic Research in the United States.** *8 by 10 in., 216 pages, paperbound; published by and available from U. S. Department of Commerce, Washington D. C., and available from Department of Commerce Field Offices; $1.50 per copy.*

This bulletin covers projects conducted at universities, hydraulic and hydrologic laboratories in the United States and Canada, and government agencies. All active projects are included. Qualified inquirers may secure information concerning any project from National Bureau of Standards or from the individual laboratories as listed in the bulletin.

FILTER FORUM

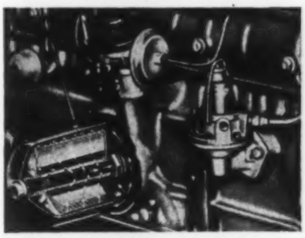


Automobile power-steering mechanism uses the filter case as a reservoir for the hydraulic oil supply.

Question:

**What do you gain by including filters in original designs?**

When installed equipment will not operate satisfactorily without filtration . . . or when cost savings and improved performance seem possible . . . filters can be added as an afterthought. But will foresight at the *planning* stage pay off in extra benefits?



Oil filter pad-mounted on side of engine crankcase.

PUROLATOR

*FIRST in the field of filtering*

Answer:

**Economy, space, accessibility, better performance**

Although it is certainly good engineering practice to put in a filter as soon as the need shows up, the benefits of anticipating that need are considerable:

**1.** A preplanned filter installation can cost less through simplification of required connections; through partial or total elimination of the filter case; or through utilization of the filter case for dual functions as in the example in our illustration.

**2.** Economical use of space and the job of "fitting things in" is more productive of good design in the plans stage.

**3.** Preplanning provides accessibility for servicing the filter and reaching other parts of the unit which might be blocked by an on-the-job filter installation.

**4.** Operating characteristics, i.e., the problem of pressure drop vs. flow characteristics can be balanced more effectively in the design phase.

**MAIL COUPON FOR DESIGN INFORMATION**

**Dept. D9-128 Purolator Products, Inc., 970 New Brunswick Ave., Rahway, N. J.**

Please send me the following filter information:

_____ Purolator's new "Filtration Manual for Designers". I'm enclosing 25¢ to cover postage and handling.

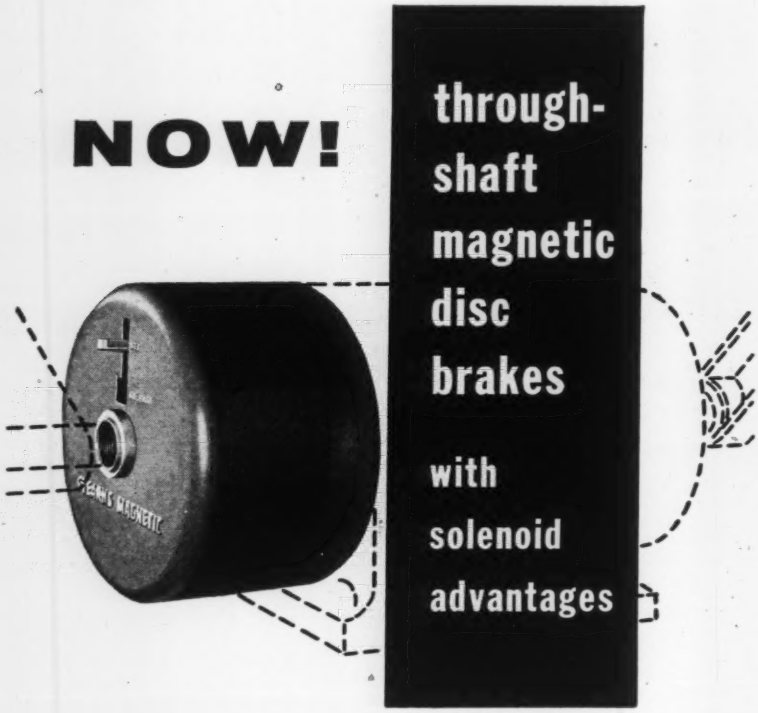
_____ Enclosed is a description of our filter problem. How should we solve it?

NAME_____ TITLE_____

COMPANY_____ ADDRESS_____

CITY_____ ZONE_____ STATE_____

*Circle 453 on page 19*



Now you can drive off both ends of a motor shaft and still take advantage of the quick-stop, instant-release features of a Stearns solenoid-type magnetic disc brake. This new brake is designed so that the motor shaft extends right through the center and out beyond the end of the brake. For motor manufacturers this permits use of a standard length shaft for Stearns brakes mounting on NEMA frames 56-C, 66-C, 182 and 184. For design engineers it means utilization of both ends of the shaft, no matter what your drive needs.

Just as important, you get all the advantages of the popular Stearns solenoid-type brake in this through-shaft construction:

**Easy maintenance** — Stearns solenoid brakes have a minimum number of parts — can be disassembled and assembled in a few minutes. Long-lasting lining easily replaced.

**Easy adjustment** — quick, accurate adjustment for torque and lining wear.

**Fast stop** — positive spring action on pressure plates. Sets automatically in case of power failure.

**Quick release** — instantaneous magnetic pull eliminates drag.

**Dust and water-resistant housings available.**

See your Stearns representative or write us for full details on this new through-shaft brake.

1141

Stearns
ELECTRIC CORPORATION
formerly
STEARNS
MAGNETIC
INC.
120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN

Circle 454 on page 19

# New Machines

## Domestic

**Radio - Phonograph:** Concerto Model TP265C high-fidelity radio-phonograph combination has compensated volume control, variable treble and bass control. Four-speed intermix record changer is equipped with automatic shutoff and automatic muting switches. Pickup has dual sapphire styli. The AM radio tuner has high sensitivity for distance reception. Six-watt amplifier uses four tubes including rectifiers and is equipped with push-pull output stage and crossover filter network. Built-in AM antenna and one 5 in. and two 6 x 9 in. front-mounted oval speakers with sound diffusers are incorporated. *Magnavox Co., Ft. Wayne, Ind.*

**Kitchen Appliances:** Twelve refrigerator models have a redesigned door which is set into the refrigerator cabinet. Some models are equipped with ice ejector which provides cubes in a storage and serving bin at the pull of a lever. Capacities range from 12.4 to 8 cu ft. Ten porcelain-finished electric ranges are available in 30 and 40-in. sizes. Line includes models with two ovens, large-capacity single ovens, and oven that broils and bakes simultaneously. One model has a fast, sealed broiler unit and filter that removes oven cooking smoke. The filter operates automatically whenever the oven is in operation. *General Motors Corp., Frigidaire Div., Dayton, O.*

**Tape Recorder:** SRT-2 high-fidelity magnetic tape recorder incorporates transistors, printed circuitry, and electrodynamic operation. The recorder covers the audible range from 30 to 15,000 cycles, utilizes all types of standard magnetic tapes in 5 and 7-in. reels, and can be installed vertically or horizontally. The dual-speed unit operates at 7½ and 3¾ in. per second, and has forward and rewind speed of 1200 ft of tape in 45 seconds. Chassis is 10½ in. high, 19 in. wide, 8½ in. deep; weight is 35 lb. *Radio Corp. of America, Theater & Sound Products Dept., Camden, N. J.*

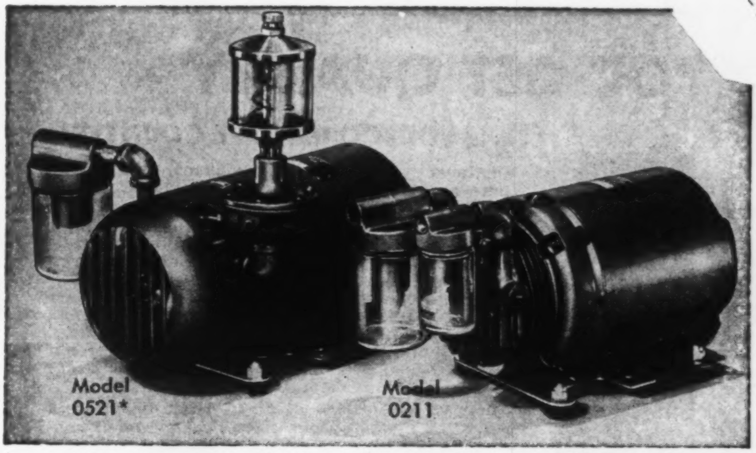
### Materials Handling

**Lift Truck:** Dust - protected, gasoline-powered industrial lift truck permits materials handling in locations containing atmospheric abrasives. Tandem air-cleaning system filters air going into the carburetor. Air passes first through a dry - type precleaner mounted on the top of the truck hood, then through a heavy-duty oil bath cleaner. A heavy-duty air filter is provided on the crankcase breather pipe. Truck bottom is equipped with a deflector plate which keeps foreign particles on the floor from being drawn up into the engine compartment. The plate can be removed easily for servicing the truck. Generator and voltage regulator are totally enclosed. *Yale & Towne Mfg. Co., Yale Materials Handling Div., Philadelphia.*

**Transfer Table:** In-line transfer table without fixtures transfers piece parts from station to station for automatic or manual operations. It can be adapted to multiple, consecutive operations and handles 6400 pieces per hr. Designed for parts having a flat surface on which to slide along a track, the table cam-locks parts at each station within 0.005-in. tolerance without auxiliary locating devices. When tolerance is less than 0.005-in., a shot pin or locating lug can be utilized. Base support contains intermittent drive unit. It is located at either end or in the middle of the table. Index distance can be varied from 3 to 9 in. and index time from 0.25 to 0.7-second. Fast indexing is accomplished with total cycle time from 0.56-second. Dwell time is adjustable. The tables are available in lengths from 5 to 12 ft. *Dixon Automatic Tool Inc., Rockford, Ill.*

### Metalworking

**Swing Lathes:** WM56P 11 and 13-in. swing lathes have heavy-



Get 10 Integral-Motor-Pump advantages in two NEW types (three models) of

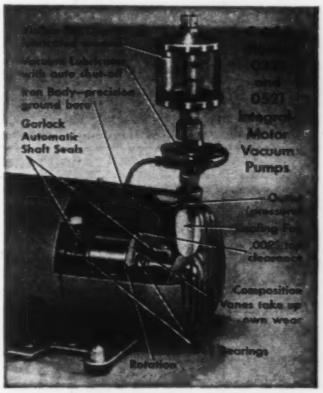
GAST rotary vane AIR PUMPS

Designers seeking a dependable vacuum or pressure source for industrial instruments, vending machines, air gauge circuits, air sampling, laboratory equipment, printing and packaging machinery, etc., will find these *new* Gast Integral-Motor Air Pumps highly advantageous, especially where compactness and portability count. Consider these outstanding features:

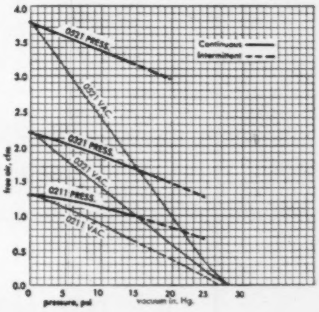
1. Latest type G.E. "Form G" motors.
2. More compact than any pump of equal capacity.
3. Total weight reduced ⅓—cuts shipping costs.
4. Motor mounting time and labor eliminated.
5. Simple, trouble-free rotary-vane design.
6. Vanes take up their own wear automatically.
7. Positive displacement, pulseless air delivery.
8. Improved appearance—smoother exterior.
9. Dependable for original equipment; plant use.
10. Forced air fan cooling on Models 0321 & 0521.

*Write for new Bulletins V-356 and P-356!*
GAST MANUFACTURING CORP.,
P. O. Box 117-P, Benton Harbor, Mich.

*0321 similar in appearance.


Vacuum Lubricator with auto shut-off
Iron Body—precision ground bore
Garlock Automatic Shaft Seals
0321 and 0521 Integral-Motor Vacuum Pumps
Outlet (pressure)
.002" top clearance
Composition Vanes take up own wear
Bearings
Rotation

Performance-Vacuum & Pressure



*Original Equipment Manufacturers for Over 25 Years*

GAST
ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

Circle 455 on page 19

YOU GET QUALITY +

.. in SODECO IMPULSE COUNTERS

Whatever your counting problems, you'll find there are SODECO Electrical Impulse Counters to solve them.

Where a large number of machines or equipment must be kept under observation and control, SODECO small, remote impulse counters with zero resetting may be the answer. They are fast—count up to 25 impulses/sec. Touch the small toggle on the front and the counter resets instantaneously. Their low power demands make them suitable for use in electronic circuits. Compactness of design makes them suitable for flush mounting.

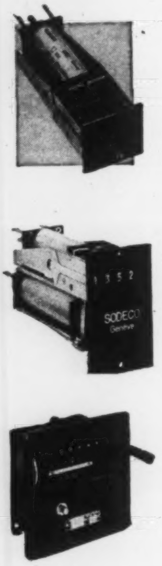
When you want an electrical reset, you'll find SODECO Instantaneous Electrical Reset Counters will do the job. They reset remotely—instantly. And they're fast—count up to 25 impulses/sec. Compact—can be flush mounted.

Or, if you need a counter for preselected counting you can get a SODECO to fit. They are fast and provide tamperproof preselection. Separated registers provide for easier reading. Manual, Electric or Automatic Reset. Low power demands of 0.8 to 3 watts.

You can always count on SODECO Counters. Write for detailed information.

LANDIS & GYR, INC.

45 West 45th Street New York 36, N. Y.



Circle 456 on page 19

Design Guide to

"Adjustable-Speed Drives ________

- ELECTRICAL
- MECHANICAL
- HYDRAULIC

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

$2.00 per copy

MACHINE DESIGN READER SERVICE

Penton Building Cleveland 13, Ohio

duty, adjustable-speed drives and spindle speeds from 40 to 300 rpm in back gear, 200 to 1800 rpm in direct drive. Speed changes are made by raising or lowering a T-handle speed-selector lever. Tachometer dial built into the headstock shows actual spindle speeds. Stops can be set on the speed selector for automatic selection of two predetermined speeds. Heavy-duty drive unit is equipped with a 2-hp, 3-phase motor. Machine also has a 54-pitch gear box and friction disk clutch for engaging power longitudinal and power cross feeds. Flame hardened bedways, taper key drive spindle noses, bed turrets and air attachments are available. Variety of bed lengths have center distances of 26, 36 and 48 in. *Sheldon Machine Co. Inc., Chicago.*

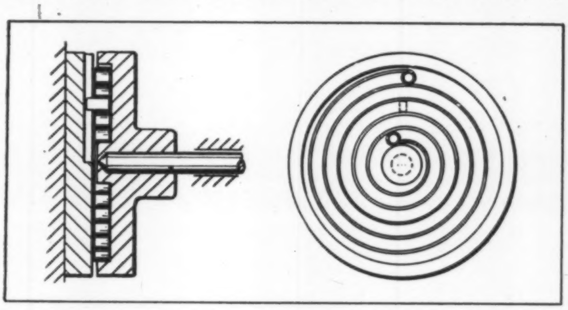
**Disk - Filing Machine:** Jemco disk-filing machine removes ferrous and nonferrous metal, wood and plastics. It can be equipped with two disks simultaneously, ranging in size from 3⅛ to 12 in. For cutting nonferrous metals, disks are available in carbon steel. Disks of high-speed steel and carbide are provided for ferrous metals. All disks have ground teeth which can be resharpened. Work table provides for mounting fixtures or sliding tables for special operations. The unit is powered by a 1-hp motor which turns disks at five standard speeds from 175 to 410 rpm. Additional speeds can be achieved by changing pulleys. *Jersey Mfg. Co., Elizabeth, N. J.*

**Cold-Heading Machine:** Headmaster solid-die, double-stroke cold header heads rivet and screw blanks at rates of 300 to 450 per minute. Toggle-actuated gate produces two blows for each flywheel revolution. Friction-roll feed makes possible maximum control in feeding. All shafts are mounted in roller bearings to reduce friction. Other features include centralized lubrication and high-tensile gray-iron cast frame. Unit heads ⅛ x ¾ rivets, No. 6 x ¾ machine screws and No. 8 x ¾ sheet metal screws. *Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.*

# NOTEWORTHY Patents

### *Rotational-Stop Mechanism*

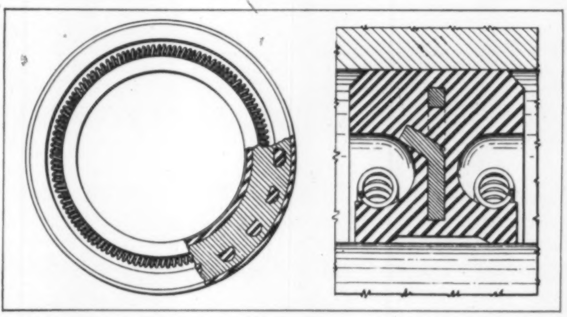
Positive stop action after a predetermined number of turns is provided by a rotational-stop mechanism employing a moving block and a fixed spiral spring



as principal components. Block tracks radially in the space between adjacent turns of the spring until it contacts stop pins at each end of the spiral. If desired, spring can be replaced by one with a different number of turns to vary allowable rotation of the controlled shaft. *Patent* 2,746,573 *assigned to Bendix Aviation Corp. by Donald F. Hastings.*

### *Mechanical Seal*

Permanent set in the flexible members of a mechanical seal is minimized by an embedded metallic reinforcing washer. Positive positioning of the washer



is ensured by its multiple tang construction. Sealing action of the flexible annular member, which is either natural or synthetic rubber, is provided by conventional garter springs. *Patent* 2,736,583 *assigned to General Motors Corp. by John T. Marvin.*

### *Multiple-Disk Clutch*

Smooth engagement and shock-free load pickup of a clutch or brake is provided by the spring action of tanged Belleville-spring disks interleaved with multiple friction disks. Tangs, spaced on the outer

**TWO** ***pressure switches for the price of*** **ONE**

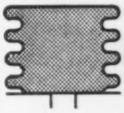
ONLY
$28¹⁰
LIST PRICE

At two predetermined set points in the same pressure system, Model 424 actuates two independent electrical circuits. One may be AC and the other DC if necessary.

***MELETRON***

**MODEL 424**

Typical applications are: in instrument air control as high-low warning, or as a lubrication system warning and safety shut down. If oil pressure drops below normal, a warning circuit is actuated and if pressure drops below the safe point, the machine is shut down.

| WE BUILD IN | WE DON'T USE |
|---|---|
| **EXTREME ACCURACY and DEPENDABILITY**<br>maintained during operating life due to direct acting design | **LINKAGES & BEARINGS**<br>which as they wear, make the setting of the pressure switch drift. |
| **OPERATION IN ANY POSITION**<br>which saves the installation costs encountered in mounting a switch that uses liquid switching elements. | **LIQUID SWITCHING ELEMENTS**<br>which make the switch difficult to mount and very critical to vibration. |
| **IMMUNITY TO VIBRATION**<br>you can mount the switch directly on your vibrating or moving equipment. |  **ACCORDION DIAPHRAGMS**<br>which make the pressure switch sensitive to vibration. |

To get complete operating data and specifications ask for bulletins 424 and 425.

**BARKSDALE VALVES**

**PRESSURE SWITCH DIVISION**

5125 Alcoa Avenue, Los Angeles 58, California

Circle 457 on page 19

Laboratory precision at mass production costs!
LINEAR
ROTO-MOLD
"O" RINGS

Do you have the facts on Linear's new, exclusive ROTO-MOLD process? It brings *automation* to the packing industry—makes possible fast delivery of perfectly uniform "O" Rings in any quantity!

★ Linear ROTO-MOLD "O" Rings are made with laboratory precision in single cavity molds under individually controlled pressure. Molding dies are automatically brought into microscopic alignment.

★ Every ROTO-MOLD "O" Ring is perfectly circular in cross section, with no transverse or other seams. You get precise uniformity without trimming or grinding.

Linear ROTO-MOLD "O" Rings are available now, in a variety of sizes and compounds, to meet your exacting requirements. Write, phone or wire for complete details.

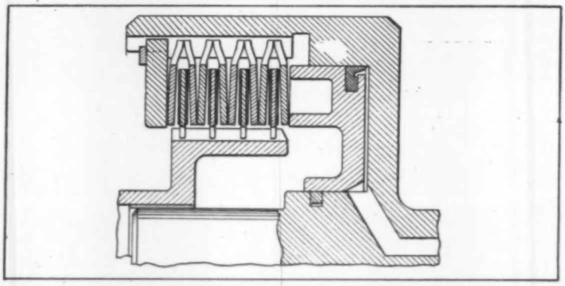
"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILADELPHIA 35, PA.

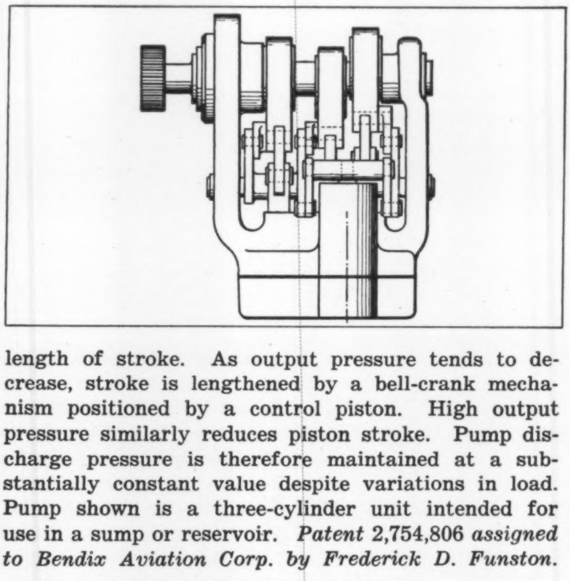
Circle 458 on page 19

peripheries of the Belleville disks, come together first when engagement of the clutch is initiated by an annular piston. Continued engaging action, with resulting flexing of the spring disks, separates the tangs, permitting full engagement of the sintered-metal friction surfaces with the spring disks. Positive disengagement is insured by the return spring action of the tangs. *Patent* 2,738,864 *assigned to Borg-Warner Corp. by Sylvan J. Becker.*



### Variable-Stroke Pump

Stroke length is varied automatically in response to changes in discharge pressure in a variable-volume, constant-pressure, piston-type pump. Volume of fluid delivered to the output manifold depends upon length of stroke. As output pressure tends to decrease, stroke is lengthened by a bell-crank mechanism positioned by a control piston. High output pressure similarly reduces piston stroke. Pump discharge pressure is therefore maintained at a substantially constant value despite variations in load. Pump shown is a three-cylinder unit intended for use in a sump or reservoir. *Patent* 2,754,806 *assigned to Bendix Aviation Corp. by Frederick D. Funston.*



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**Thermally controlled valve** for accurately bleeding minute quantities of fluid into high-vacuum systems makes use of the difference in thermal expansion between the valve plug and a surrounding, electrically heated tube. Flow through valve can be controlled from a few molecules to a steady stream at output pressures as low as $10^{-9}$-mm Hg. *Patent* 2,749,934 *assigned to E. I. du Pont de Nemours by Ralph G. Nester.*

# MACHINE DESIGN

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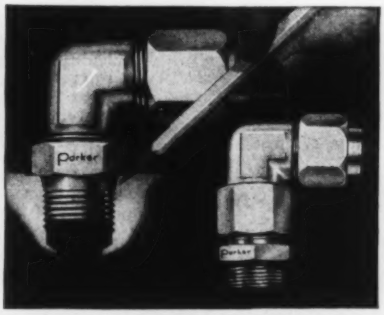

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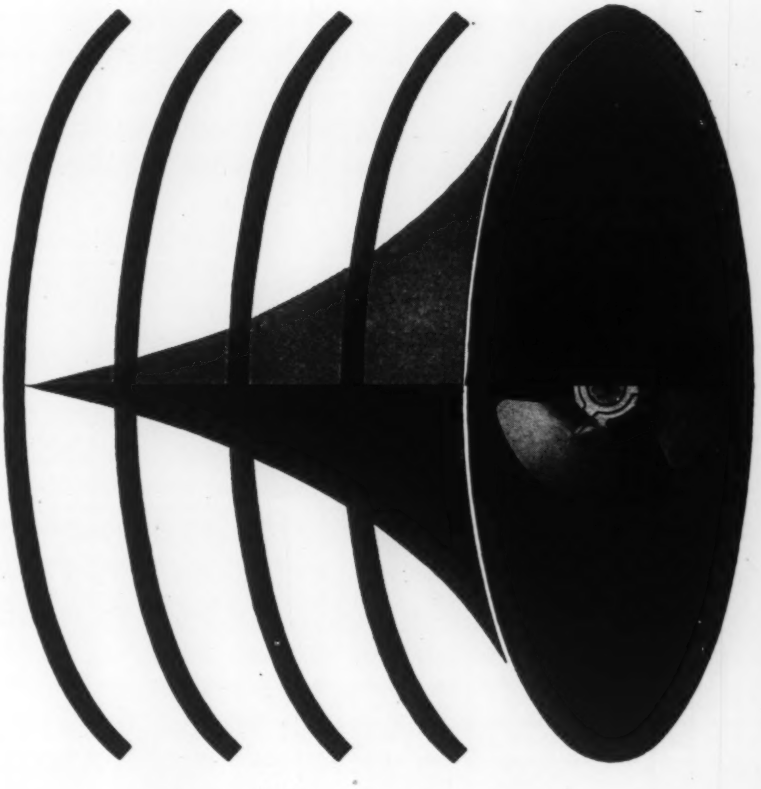

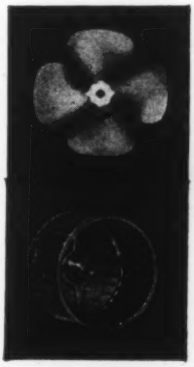

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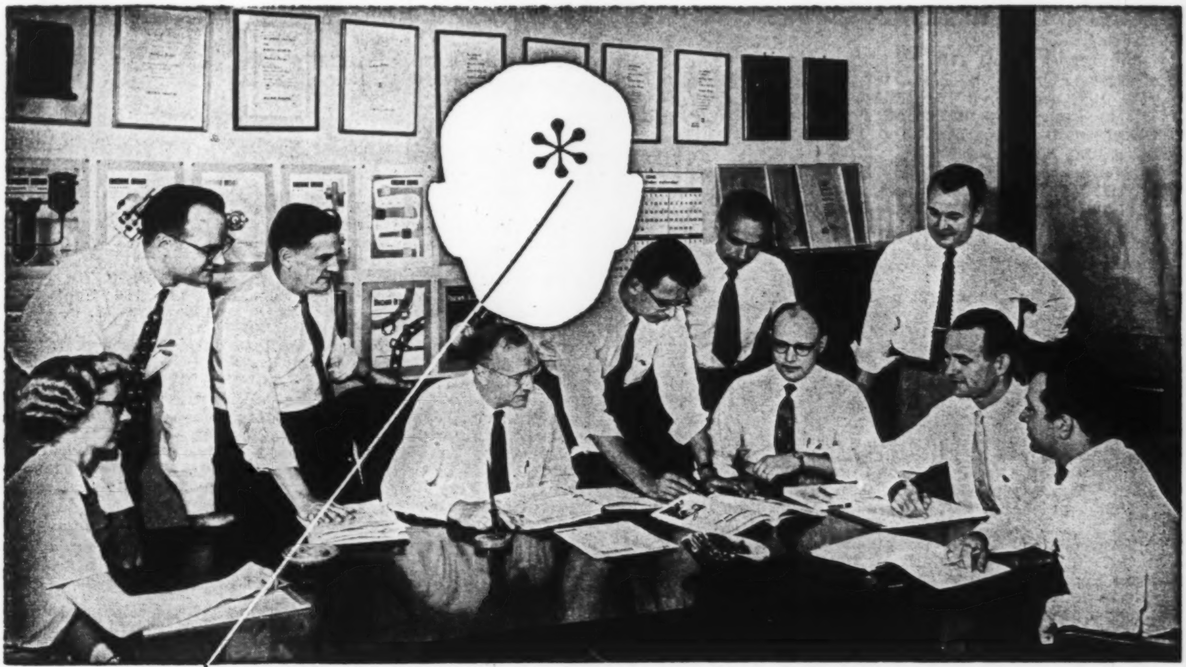

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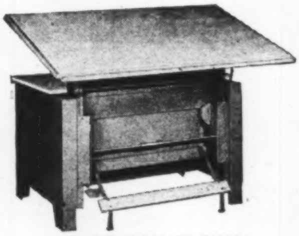

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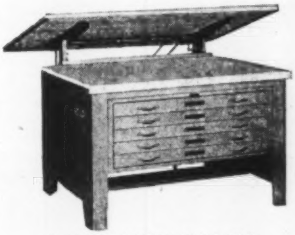

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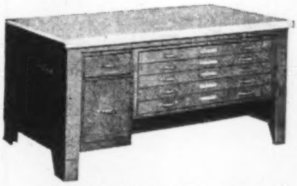

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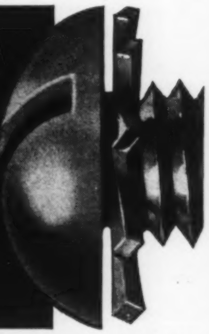

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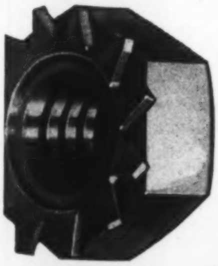

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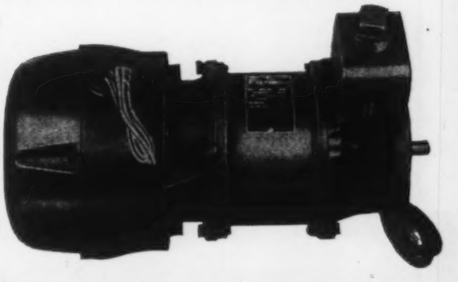

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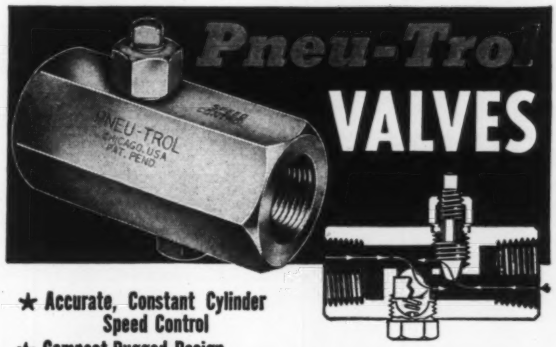
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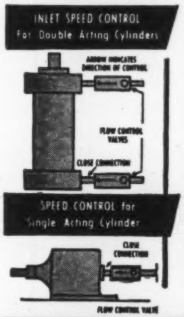
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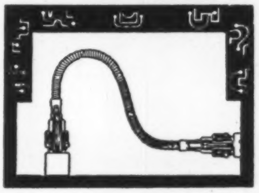

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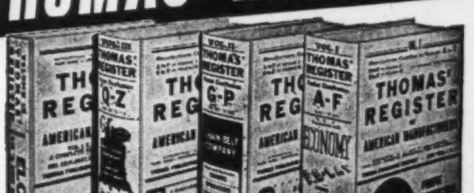
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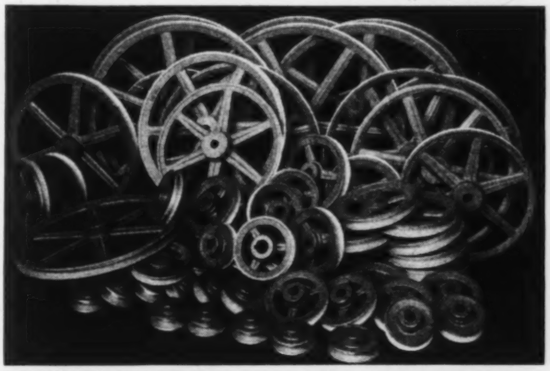
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BPA NBP

# WANTED

## Technical Editor

Here is a real challenge for the right man with enthusiasm for writing and a strong creative urge to broaden his perspective and assist industry in effectively applying the techniques of automation.

Edited by a competent staff of experienced engineers, AUTOMATION has an opening for an engineer with diversified manufacturing or production equipment design background and editorial or other writing experience. He should be able to write well, be familiar with automation engineering and have evidence of same.

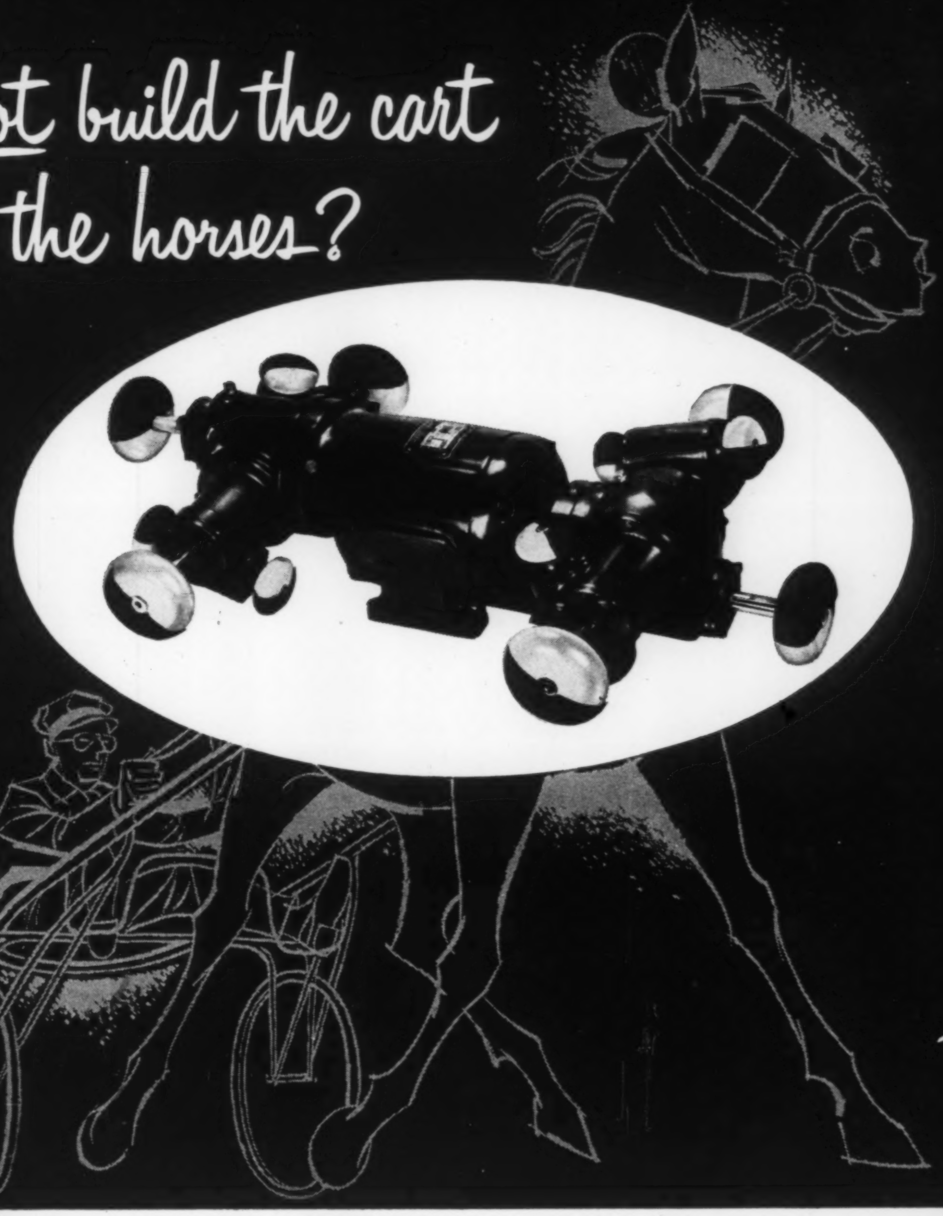
Duties include development, writing, editing articles and feature departments.

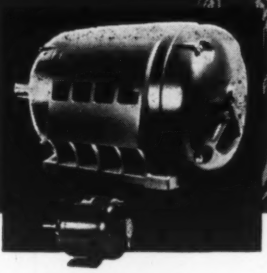
There will be opportunity to travel on editorial assignments and attend meetings, expositions, etc.

Headquarters in Cleveland, Ohio.

If you are interested and feel qualified, please send full details of your practical engineering and writing experience to the Editor, AUTOMATION, Penton Building, Cleveland 13, Ohio.

# Why not build the cart before the horses?





Just tell us here at Master what you want in power drives—and get the utmost in flexibility, compactness and performance. It probably won't be as complicated as the multi-shaft Gearmotor illustrated here, with 14 shafts turning at diverse speeds. But, regardless of what you need, Master can supply the right combination of horsepower, shaft speed and mounting features with whatever Master components are required—all combined in one compact efficient unit. Just ask for information.

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| **Motor Ratings** | 1/8 to 400 H.P. All phases, voltages and frequencies. |
| **Motor Types** | Squirrel cage, slip ring, synchronous, repulsion-start induction, capacitor, direct current. |
| **Construction** | Open, enclosed, splash-proof, fan-cooled, explosion-proof, special purpose. |
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| **Power Drive Features** | Electric brakes (2 types)—5 types of gear reduction up to 432 to 1 ratio. Mechanical and electronic variable speed units—fluid drives—every type of mounting. |

THE MASTER ELECTRIC COMPANY, Dayton 1, Ohio

# How TIMKEN® bearings maintain spindle precision, accurate gear mesh on extra heavy-duty lathe

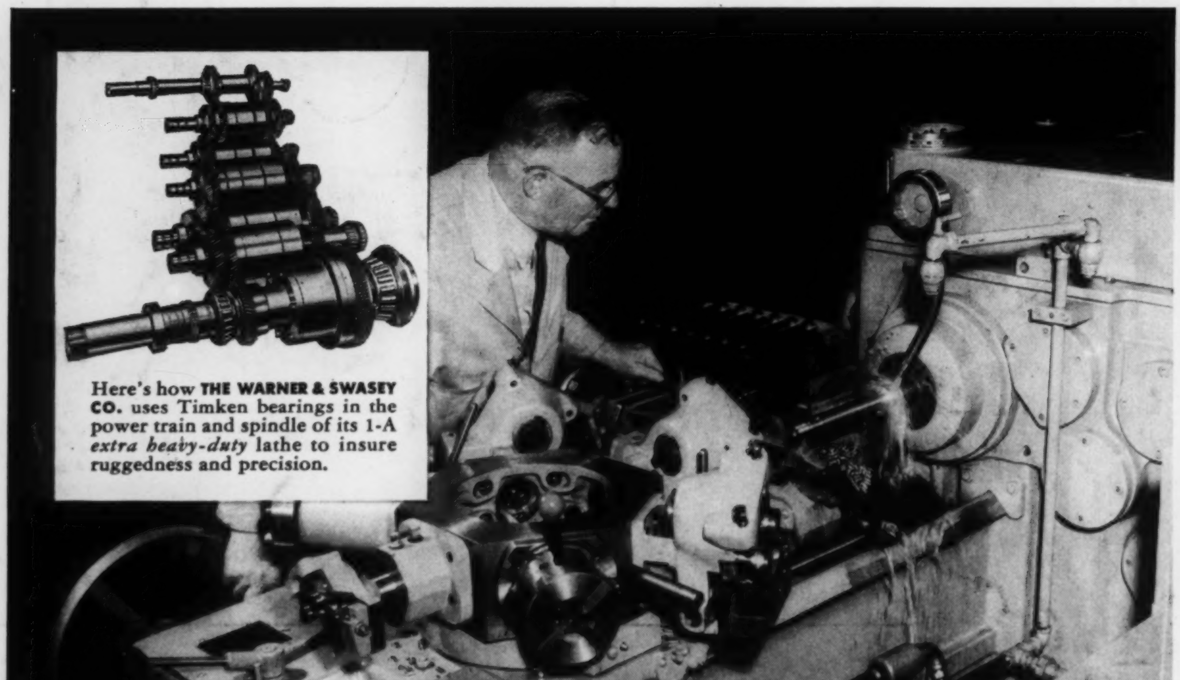
AT the flick of a lever, the operator of this Warner & Swasey 1-A *extra heavy-duty* lathe can get any one of 16 spindle speeds immediately. Then, with the right speed for the job, this lathe can hog off a lot of metal fast—and still turn out close-tolerance parts.

To help assure both precision and ruggedness, at any speed, Warner & Swasey engineers have mounted the spindle and gear train on Timken® tapered roller bearings. Timken bearings maintain spindle precision and accurate gear mesh day in and day out, piece after piece. They're tapered to take both radial and thrust loads, in any combination. Full line contact between rollers and races provides maximum capacity. Shafts are held in alignment. Gear mesh is smoother, more accurate. Shaft wear is eliminated, gear wear reduced.

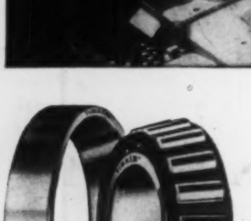
True rolling motion, plus almost microscopically smooth surfaces combine to make Timken bearings practically friction-free. They're made from Timken fine alloy steel. We're the only bearing manufacturer in America that makes its own steel. Rollers and races of Timken bearings are case-hardened for hard, wear-resistant surfaces and tough, shock-resistant cores.

No other bearings can offer you all the advantages of Timken bearings. That's why so many manufacturers of fine equipment use them. Whether you build or buy machinery, be sure to specify Timken bearings. And look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

*This symbol on a product means its bearings are the best.*



Here's how **THE WARNER & SWASEY CO.** uses Timken bearings in the power train and spindle of its 1-A *extra heavy-duty* lathe to insure ruggedness and precision.



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*TAPERED ROLLER BEARINGS*

**REVOLUTIONARY BUCYRUS PLANT HELPS HOLD DOWN RISING COSTS**

At a new plant in Bucyrus, Ohio, the Timken Company has substantially reduced the cost of tapered roller bearings by: 1) producing these bearings under a new system of extreme mechanization; 2) standardizing on 13 bearing sizes with the widest applications throughout industry. Manufacturers can take advantage of these lower costs by redesigning applications to use these Bucyrus sizes. And as more switch to Bucyrus bearings, production costs can drop still further, meaning even lower costs to you.

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION

*Circle 403 on page 19*